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ABSTRACT

The third of three volumes of papers presented at the 1979 ADCIS convention, this collection includes 30 papers presented to special interest groups--implementation, minicomputer users, National Consortium for Computer Based Music Instruction, and PLATO users. Papers presented to the implementation interest group were concerned with faculty reactions to CAI tutorials, review lessons in English compositions, thematic information text revisions, self-paced instruction, problem solving with automatic mediation, linear programmed instruction compared with CAI, the computer in educational institutions, CMI and student achievement, software development, and the role of the computer programmer. Minicomputer projects described focused on self-paced learning, a shared CAI control program, as a classroom teaching tool, the current state of the field, the development of PILOT, and personal computers. Music educators heard papers on courseware development for microcomputers, CAI in music theory, evaluation of competency based aural training, and ear training for non-music majors. Reports on PLATO included the teaching of sex education, process operator training, foundation visual design, adult basic skills, and optical letterspacing, as well as on precision motion analysis in biomechanics, microprocessor courseware delivery, and the development of a user's guide. Some papers include flow charts, diagrams, data tables, models, and/or bibliographies. (RAO)

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MISSION OF THE FUTURE

PROCEEDINGS OF THE ANNUAL CONVENTION

OF THE

ASSOCIATION FOR THE DEVELOPMENT OF COMPUTER-BASED INSTRUCTIONAL SYSTEMS

VOLUME III

A. IMPLEMENTAION SPECIAL INTEREST GROUP
B. MINICOMPUTER USERS INTEREST GROUP
C. NATIONAL CONSORTIUM FOR COMPUTER BASED MUSIC INSTRUCTION
D. PLATO USERS INTEREST GROUP

1979

ISLANDIA HYATT HOUSE

SAN DIEGO, CALIFORNIA

FEBRUARY 27 TO MARCH 1

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Faculty Reactions to Implementing of CAI Tutorials: What Can Happen and What to Expect

Robert E. Burns
William I. Davisson

Since 1973, a group of historians and instructional materials specialists have developed and implemented a computer-assisted instruction segment for a two-semester course in Western Civilization. Originally conceptualized as "500 Questions in Western Civilization," the Notre Dame program consists today of more than 600 Tutorial questions covering the history of the Western world from the fall of Rome to the present time.

A typical tutorial lesson consists of about 12 questions presented in a four-option multiple-choice format with programmed responses for each answer choice. Each question is preceded by a lead which helps to place the question in a historical context. These leads vary in length from a short sentence to a full paragraph. Programmed responses vary in length from two or three sentences to about half a page. In total, the tutorials -- leads, questions, and responses -- represent more than 2,400 double-spaced pages.

The Notre Dame tutorials are intended to be textbook independent and have been classified by function into three types: basic events tutorials deal with historical subject matter and/or statistical data of sufficient importance to be included in any Western Civilization course; information delivery tutorials are special emphasis items and meet the curricular needs of individual professors; and concept analysis tutorials deal with such historical abstractions as feudalism, mercantilism, and romanticism and are presented both as a sequenced series or as single items.

Student Reactions

Using CAI tutorials have proven to be both successful and popular with students. Though the formal evaluations undertaken to date have been concerned only with student satisfaction, the results have been extremely positive. Of the students surveyed (N=101) 85% reported high satisfaction with the tutorials and a willingness to recommend other courses using CAI to their friends. An even greater number of students -- 93% -- believed that time invested in operating the tutorials resulted in better scores on examinations. 80% indicated a willingness to enroll in other courses using CAI tutorials, while 78% believed that they learned more from running CAI tutorials than from discussion sessions led by graduate assistants. Only 9% reported the CAI tutorials as impersonal and/or dehumanizing and 6% described them as a waste of time. Follow-up interviews with students tended to confirm what the data suggested. Most students seemed to be using the tutorials as sources of information rather than as simple review routines. Moreover, students deliberately select incorrect answer-choices for the information contained in the responses. It seems that grade conscious students perceived the tutorials as giving such a competitive advantage in preparing for examinations that they feel compelled to get every bit of information out of them. In general, most students were convinced that the time invested in running CAI tutorials was well spent.

Faculty Reactions

Faculty reactions to the introduction of large segments of CAI into on-going or new courses have been mixed. Many faculty have been pleased by the experience; others have been disenchanted. A few have absolutely refused to have anything to do with CAI at all. However, every faculty in departments where CAI projects are underway have been forced to reassess their roles as teachers and think seriously about pedagogy.

Our experience suggests that CAI implementation problems will be minimal with teachers comfortable in discussion-oriented instructional modes and most acute with coverage oriented lecturers. For faculty who perceive their primary teaching role as that of discussion facilitator or critic, the introduction of CAI tutorials can be a welcome release from a burden uneasily borne. Heretofore, the obligation of coverage has weighed heavily upon many such teachers and has distracted them from doing what they do best. Because CAI tutorials provide students with such an abundance of factual information in an easily accessible and manageable form, the effect of using CAI tutorials upon such faculty has been extremely positive. This very positive effect has been briefly described elsewhere as "freeing teachers to teach."[1]

For faculty who see their primary teaching role as that of lecturer and information deliverer, the introduction of CAI tutorials can be a thoroughly unnerving experience. The rehearsal of one such case involving a much respected professor will at once reveal the nature of CAI implementation problems and suggest strategies for resolving them.

One Man's Experience

Our decision to introduce CAI tutorials into an on-going course in Western Civilization was not lightly made. Several teachers were approached, and after lengthy question and answer sessions about what CAI tutorials were and how they worked, one very popular teacher agreed to try them in his course. This teacher was an experienced lecturer with a well deserved reputation for performing well before large groups. He was a successful and well published scholar in two specialized historical fields. At the same time, he perceived himself to be entirely comfortable with the generalizations and necessary oversimplifications that Western Civilization courses sometimes require.

The organization of the course into which our CAI tutorials were to be introduced was conventional. It consisted of a lecturer and graduate student discussion leader. The lecturer chose the books, prepared the syllabus, and oversaw the selection and organization of tutorial questions into lessons appropriate to lecture contents and reading assignments. Our lecturer was generally unacquainted with the current theoretical and research literature of pedagogy. He had no special expertise in testing and evaluation procedures and no previous experience in developing applications of instructional technology. Though he had a general knowledge of the content of the tutorials -- about as detailed as his knowledge of the books selected for the course -- he had no experience in writing or designing them. He had not been asked to write any tutorials and indicated no strong desire to do so. Simply stated, he was a successful traditional teacher who was willing to try to use applications of instructional technology that others had developed. In all of this, he was typical of many in our profession; and in being typical, he was also totally unprepared for the way this new technology would impact on him and the way he did his job.

When the course was taught, student satisfaction with it was high. However, for the lecturer it turned out to be a very frustrating experience. He described it as one of the most trying and exasperating classes that he had ever taught. The problem for our lecturer was misperception of what CAI tutorials could do. He had perceived them functioning solely as review routines -- as useful supplements to the lectures and reading assignments. He neither appreciated the information-delivery capability of the tutorials nor anticipated how much use of that capability students would make through deliberate selection of wrong answer-choices. The nature of the problem was best articulated by the lecturer in a comment after the course was over that he believed somehow he had lost control of the course. This feeling of loss of control was in part a reaction to student complaints about occasional system breadkowns and poor response time, but it followed principally from his growing recognition that his own role in the course was being diminished.

In the course organization as originally conceived by the lecturer, coverage and chronology were to be left to the reading assignments. The lectures were intended to be largely in-depth single-subject presentations which illustrated or clarified a given theme or problem. The CAI tutorials were to be review routines. What happened was that the information-delivery and concept-analysis tutorials turned out to be in-depth single subject presentations which competed with those given by the lecturer. To be sure, they were less detailed and less persuasively delivered. But being CAI tutorials they were retrievable on demand.

The heart of the matter was a failure to integrate the content of the lectures with the subject-matter of the tutorials. The point here is not repetition or overlapping. It is that the tutorials and lectures seemed unconnected. On the one hand, for the lecturer the tutorials seemed adrift from what he was trying to do in the classroom. The effect was much like using books in a course that had been skimmed rather than read. One was never really certain what was in them. On the other hand, because students were spending more time with the tutorials than with the lecturer, for them it appeared that he was adrift from the tutorials. Students were with the lecturer on a given subject for fifty minutes at a sitting. They could interface with a terminal and run CAI tutorials on a subject as long or as often as needed. After a lecture students have their notes; after running CAI tutorials students have a printed record of what they have done. Our lecturer discovered that the enormous information-delivery capability of CAI tutorials effectively precluded them from functioning simply as helpful supplements to his lectures. The CAI tutorials had become the heart of his course -- the medium through which the most basic and essential factual information was organized and presented.

Another problem encountered while teaching the course was growing student dissatisfaction with the kinds of questions given to them as part of their regular examination procedure. All of the major course examinations included both objective and essay questions. Student satisfaction with the fairness of the objective parts of the examinations was very high (92%) while satisfaction with the essay questions was low (50%). As written, these essay questions were typical of the kinds of questions that the lecturer had been giving to students for the past ten years. They were open-ended and intended to give students opportunities to write all they knew or could recall about the subject matter under examination. Students complained about what they perceived to be the arbitrary and capricious fashion in which these generally open-ended and undirected essay questions were graded.

It would appear that the experience of running several hundred carefully prepared CAI tutorials sensitized many of the students in the course to what constituted good test questions. Good questions were questions which could be answered by students out of materials studied and which could be graded fairly according to known criteria. Most of the students who were actively involved in running CAI tutorials came to resent broad open-ended essay-type examinations wherein answers to questions were defined according to the sophistication or lack thereof of the persons taking the examination. When confronted by such questions on history examinations, our students compalired about them, generally perceived themselves as being arbitrarily graded, and went away with the idea that history was a matter of opinion. Such an outcome had been neither anticipated nor desired by our lecturer. He saw himself in some inexplicable fashion as having been victimized by a machine, and after this one experience no longer wanted to participate in courses with CAI segments.

Problem Identification and Solution Strategies

Analysis of the reactions of our lecturer to his experiences with CAI tutorials identified three needs if the potential of this instructional mode was to be realized. First, a user selection program had to be designed whereby lecturers could chose from our inventory of tutorials only those which related directly to the content objectives of their classroom presentations. Second, the lectures in this course had to be reorganized and recast in order to relate more closely to the subject matter of the tutorials. Third, short term in-service workshops should be established wherein CAI applications could be explained and examined, non-lecture mode teaching techniques demonstrated, and test preparation skills improved.

The first step towards meeting the needs identified above was to develop a user selection program. It was designed and written in such a way that teachers were able to chose from our total inventory any number of tutorials and organize them into any number of lesson configurations. This program also allows teachers to write new tutorials and appropriately sequence them in either new or existing lessons. Once selection had been made, the program will renumber tutorials within lessons as well as renumber the lessons themselves.

Next, a new lecturer was appointed. He was an experienced teacher of history with a serious interest and some publications in pedagogy. Even more important, he was a true believer in the value of CAI tutorials and was himself an experienced tutorial writer. He agreed to prepare a detailed syllabus with content objectives specified on day by day basis. These objectives were derived from the subject matter of the tutorial lesson assigned for a given day. A new lecture series organized around the content objectives specified in the syllabus was prepared. These new lectures were intended to expand, clarify, and when appropriate provide historiographical perspectives for the themes, problems, and concepts examined in the tutorial lessons. Thus were the lectures and tutorials integrated through the device of a detailed syllabus.

Finally, a series of five presentation-discussion sessions styled teaching-learning workshops for newly hired assistant professors, teaching assistants, and interested regular faculty on a voluntary basis were organized as prototypes for future in-service faculty workshops. Two sessions were devoted to CAI applications and one each to test preparation, discussion mode instructional techniques, and alternatives to chalk and talk.

Results of Solution Strategy Implementation

Together these three strategies have contributed to the expansion of CAI applications but not in the manner anticipated. Neither the availability of a user selection program, in service-workshop opportunities, nor the example of a successful on-going course has had much effect in expanding CAI applications in courses offered by the history department. Except for the faculty directly involved in tutorial writing or in using them in the reorganized western civilization course, the impact of CAI on other members of the history department has been minimal. Faculty attitudes ranged from slight interest to open hostility. Most were indifferent. To be sure, the majority of the department thought that the idea of a user selection program was good and that in-service workshops would do little harm, but few if any faculty have actually employed the user selection program or attended the workshops. Graduate students regularly use the tutorials in preparing for their candidacy examinations and graduate student teaching assistants in that department have attended the workshops with profit and satis faction. Generally, regular history department faculty have remained distant from CAI applications.

In part this consequence has followed from the experiences of our first lecture, but it also has found much support in long standing attitudes towards the value of pedagogy. The attitude of the senior professors in the department was that CAI applications were interesting and possibly even helpful to students, but that CAI as well as other non-lecture instructional strategies were not worth the time and money required to implement them. They were not really important activities, certainly not as important as historical research and publication. If one did instructional work, one simply did it and should not expect that such work would influence departmental promotion and retention decisions. Right or wrong, the majority of the senior professors in the History department believed that instructional development work is simply irrelevant to promotion and retention decisions. Consequently, younger faculty have been discouraged from contributing their time to such activities. The burden of the work fell upon those few people who were willing to put aside personal research and undertake complex and lengthy writing and programming tasks which most of their departmental colleagues either ignored, did not understand, or disdained.

However, the attitude of the majority of the History department faculty toward instructional development activities is not a general one at our university. It prevails there and perhaps in a few other departments. In most of our departments instructional development activities of this type are highly valued and have been generally accepted as one of several criteria for promotion and retention.

In several departments throughout our university the progress of CAI work begun in the History department was watched with great interest and has inspired emulation. A group in the Economics department has developed and implemented a large set of tutorials and excerises for their introductory Economics Principles courses. Two members of our English department have prepared a highly successful CAI segment for our Freshman Composition course. Students needing extra work and drill in comma useage, sentence patterns, pronoun reference, etc. are referred by their instructors to tutorials which will meet those needs. Presently, approximately 900 students are using some or all of these tutorials. We also have CAI segments in various stages of development and implementation for courses in Symbolic Logic, Social Problems, Introduction to Scripture, and General Biology.

The work begun in the History department has inspired development of tutorials in a range of subject-matters across our university. The progress of CAI from that of a hopeful idea in the minds of two or three true believers to its present place in the instructional environment at our university has been neither steady nor easy. The need for a user selection program turned out to be not as pressing as the experience of our first history lecturer suggested. It is a feature whose availability helps teachers decide to give CAI a try, but it is rarely used. Tutorials in subject matter areas such as Western Civilization, English grammar, and Economic Principles are in such short supply that very few of those which are available are rejected.

The workshops have been very helpful for those who have attended them. Even though very few of the thirty-five regular faculty and teaching assistants presently staffing our Freshman Composition courses were true believers in CAI when it was introduced into this course, because of the workshops the unhappy experiences of our first history lecturer have not been repeated. Moreover, satisfaction with the workshops has been sufficiently encouraging that the idea has been expanded into a university wide faculty development program. A proposal for such a program has been written and has been submitted to a private foundation.

Conclusion

If there is a message in our experience with meaning for other institutions contemplating development or implementation of CAI materials, it is that implementation of CAI will encourage changes in both how courses are taught and what is taught. Administrators must be prepared to respond to genuine faculty needs created by CAI implementation with both policies and mechanisms. Faculty using CAI tutorials will have to adjust the mode and content of their presentations to the subject matter of the tutorials. Time, technical assistance, and perhaps even some money may be required to enable them to do so. Faculty must prepare themselves to be able to respond to students in ways that programmed tutorials cannot. If faculty are deficient in the skills and techniques of discussion-mode instruction, opportunities should be provided for them to improve the former and learn the latter. In a phrase, implementing CAI tutorials will create a situation where lecturers will have to try to become teachers.

Computer-Aided Review Lessons in English Composition

Edward A. Kline
Director, Freshman Writing Programs
University of Notre Dame

The use of computers to assist students in the mastery of English composition and the related skills of grammar, spelling, and punctuation is not a new phenomenon.[1] However, the majority of these computer-assisted programs are devoted totally to grammar and related skills or to the stylistics of composition: structural variety, word counts, cliches, direct discourse, etc As valuable and helpful as these aspects of writing as contained in the noted programs have proven to be, they do exactly what they were designed to do, which is to say that they are not concerned with the process of composition *per se*. The programs described herein are designed for use as a second or concurrent phase to follow or to be used with the aforementioned programs.

Writing is a skill and an art, and, as such, involves the mastery of grammar and rhetoric. The roles of grammar and rhetoric in the compositional process are perhaps best exemplified by comparing composition to an athletic contest. Grammar represents the rules and conventions of the game; rhetoric represents the maneuvers, or the choice of plays that enables a team or individual to score points. Mastery of grammar alone seldom leads to correct writing beyond the limits of the sentence. Knowledge of rhetoric alone is a mere academic exercise. As an abstract body of knowledge, rhetoric can be manifested in written or oral form only through the discipline of grammar. Just as no individual or team wins an athletic contest by mastery of the rules or maneuvers in isolation, no student is successful in mastering English composition by the isolated study of grammar or rhetoric. Traditionally, grammar has been studied by students as the beginning point in the composition process, culminating in the sentence and the paragraph; rhetoric was not formally studied, except in a few high schools with enlightened and energetic teachers, until the freshman year of college, when, it was assumed, fairly, unfairly, or at least in expectation, that the student had mastered grammar. The Collegiate freshman year became and still is, in most cases, the first experience the student encounters where the medieval trivium of grammar, rhetoric, and logic are united.

The teacher of English composition on the college freshman level faces a number of challenges. Students, despite college entrance requirements and high school diplomas, are deficient in the skills of grammar and usage. Yet the instructor is expected to teach composition, building upon the students' knowledge of grammar, "the rules of the game," by adding rhetoric, "the maneuvers of the game." Compounding this binary difficulty is acknowledgment of the fact that rhetoric is being taught before students have been taught to think; hence, a third element enters to further complicate matters: logic, the art of accurate reasoning, of describing relationships. The absence of logic in the compositional process, again in comparison to an athletic contest, is akin to deliberately kicking a football over the opponent's goal posts or dribbling a basketball helter-skelter in mid-court.

Acknowledging the traditionally followed belief and practice that mastery of sentence grammar precedes the mastery of rhetoric, i.e., paragraph and essay construction, the author developed and made available for use 57 CAI review modules containing 408 review points devoted to the skills of morphology-syntax, punctuation, spelling, and phonology. Phase II of this project is concerned with the development of CAI review modules in the arts of rhetoric-logic.

Written in the FORTRAN language, the composition review programs are tripartite.[2] Part I enables the designer of the review materials to actually set up the format of the review module: exposition of a principle, exemplification of the principle, and presentation of a series of multiple choice type questions to which the user responds. Part II of the system's design controls student access of the operations between the terminal and the computer, and Part III is the repository for the editing functions which permit the initial designer of the programs' contents or an individual teacher to add, delete, change the order of questions or answers, etc.

The review modules do not teach a student to write *per se*, since one best learns to write by writing; however, the modules do describe and exemplify the basic principles of composition, one at a time, and then test the user's understanding or comprehension of the principle. The modules are designed to re-enforce the aspects of rhetoric and logic that are first presented in a composition class by an instructor or first read in a book by the user. This re-enforcement, combined with practice in the recognition of correct and incorrect examples of writing contained in the question-response section of the modules, it has been found, leads to a quicker mastery of the artistic aspects that underlie composition.

The approach to the subject matter is independent of any one rhetoric or composition textbook, although it is unabashedly and unapologetically Aristolian in bias. The content, as listed, is not sequential, although the module devoted to "Discovery Procedures" is a recommended starting point.

MODULE TITLE	SPECIFIC CONTENTS
1. Discovery Procedures:	topic delimitation thesis statements thesis restriction thesis unity thesis precision thesis paragraphs justification sentences faulty thesis devices
2. Essay Coherence:	logical associational spatial chronological grammatical
3. Essay Emphasis:	direct statement positioning proportion isolation repetition faulty devices

4. Paragraph Construction:
   - topic sentence types
   - unity
   - completeness
   - orderly movement
   - coherence
5. Conclusions:
   - short
   - extended
   - paragraphs
   - dictional devices
6. The Word:
   - usage levels
   - etymology
   - general and specific
   - concrete and abstract
   - literal and figurative
   - jargon
   - euphemisms
   - selected figures of speech
7. Classification:
   - purpose
   - binary
   - complex
   - uses in writing
8. Identification:
   - contextual
   - placement
   - empirical characteristics
   - statistics
   - uses in writing
9. Comparison and Contrast:
   - significant and casual
   - purpose and system
   - presentation patterns
   - uses in writing
10. Analysis:
    - differentiated from classification
    - technical analysis
    - process analysis
    - presentation in writing
    - cause and effect analysis
    - causes and conditions
    - the report
    - the judgment

    - the inference
    - uses in writing

11. Description:
    - general to specific
    - the dominant impression
    - objective
    - impressionistic
    - the point of view
    - the fundamental image
    - selection and order
    - diction
    - uses in writing

12. Persuasion:
    - occasion
    - persuasive appeal
    - evidence
    - attitude
    - fairness
    - concessions
    - refutation
    - appeal
    - conviction and action
    - uses in writing

13. Argumentation:
    - the common ground
    - unarguable subjects
    - the single proposition
    - proposition of fact
    - proposition of action
    - simple and complex issues
    - evidence
    - induction and probability
    - the inductive leap
    - analogical induction
    - deduction and certitude
    - single and double premises
    - restrictives
    - fallacies

14. Definition:
    - purpose
    - parts and process
    - common ground
    - stipulative
    - essential
    - descriptive

		connotative etymological fallacies uses in writing
15.	Diction:	audience abstractions ambiguity word order figures of speech
16.	Sentence Rhetoric:	loose periodic emphatic
17.	Tone and Tonal Devices	writer's attitude subject and occasion the reader qualification of meaning literal and ironic over and understatement tonal dangers special and ideal audiences
18.	Illustration:	series extended relevant uses in writing
19.	Purpose:	directionless writing non-selectivity uncritical writing.

At this point, a few excerpts from the modules are in order to exemplify and to make concrete the contents of a review module. The first two excerpts are from the module devoted to "Definition." The first extract, item 3 in the module, exemplifies the principle of definition construction in terms of the sentence. The second extract, item 9 in the same series, illustrates the applications of definition on the paragraph level:

Definition: Item 3

IT WAS EARLIER MENTIONED THAT DEFINITION ANSWERS THE QUESTION "WHAT IS IT? AND DOES SO BY POINTING TO A SUBJECT, NOT IN TIME OR SPACE AS IN THE RHETORICAL PROCESS CALLED IDENTIFICATION, BUT ACCORDING TO ANOTHER SCHEME. DEFINITION INDICATES THE CLASS INTO WHICH A THING MAY BE PUT AND THEN POINTS OUT HOW THE "TO BE DEFINED PORTION" DIFFERS FROM OTHER THINGS THAT BELONG TO THE SAME GENERAL CLASS. WHEN WE PROPERLY DEFINE, WE LOCATE THE "TO BE DEFINED PORTION" AS A SPECIES IN RELATION TO A GROUP (GENUS). THE GROUP OR GENUS MAY CONTAIN SEVERAL SPECIES: THE GOOD DEFINITION INDICATES WHICH QUALITIES DISTINGUISH THE GROUP. THE RESULTANT FORMULA FOR GOOD DEFINITION, THEN IS:

DEFINITION OF SPECIES=GENUS PLUS DIFFERENCES (DIFFERENTIAE)
THE TO BE DEFINED=THE DEFINER
THE TO BE DEFINED: GENUS: DIFFERENCES:

A TRIANGLE IS A GEOMETRICAL FIGURE WITH THREE SIDES.

A SQUARE IS A GEOMETRICAL FIGURE WITH FOUR EQUAL SIDES.

FROM THE DEFINITIONS BELOW, SELECT THE ONE WHICH LACKS DIFFERENTIAE; TYPE THE NUMBER THAT APPEARS BEFORE IT.

1. A HOUSE IS A MAN-MADE SHELTER.
2. A LANCE IS A THRUSTING WEAPON CONSISTING OF A LONG WOODEN SHAFT WITH A SHARP METAL SPEARHEAD.
3. A PILL IS A SMALL BALL OR PELLET OF MEDICINE TO BE SWALLOWED WHOLE.
4. A RACKET IS A LIGHT BAT FOR TENNIS, BADMINTON, ETC. WITH A NETWORK OF CATGUT, SILK, NYLON, ETC. IN AN OVAL OR ROUND FRAME ATTACHED TO A HANDLE.
5. RACKET IS LOUD AND CONFUSED TALK OR ACTIVITY.

QUESTION 3 RESPONSE 1

CORRECT. THIS DEFINITION CONTAINS GENUS ONLY. THERE ARE OTHER MAN-MADE SHELTERS THAT ARE NOT HOUSES: TENTS, CAMPERS, BARNS, ETC.

QUESTION 3 RESPONSE 2
INCORRECT. THIS DEFINITION CONTAINS GENUS: WEAPON, AND DIFFERENTIAE: THRUSTING, LONG WOODEN SHAFT, SHARP METAL SPEARHEAD.
TRY ANOTHER ANSWER.

QUESTION 3 RESPONSE 3
INCORRECT. THE DEFINITION CONTAINS GENUS: MEDICINE, AND DIFFERENTIAE: SMALL BALL OR PELLET TO BE SWALLOWED WHOLE.
TRY ANOTHER ANSWER.

QUESTION 3 RESPONSE 4
INCORRECT. THE DEFINITION CONTAINS GENUS: BAT FOR TENNIS OR BADMINTON, AND DIFFERENTIAE: LIGHT, NETWORK, ROUND OR OVAL IN SHAPE.
TRY ANOTHER ANSWER.

QUESTION 3 RESPONSE 5
INCORRECT. THE DEFINITION CONTAINS GENUS: TALK OR ACTIVITY, AND DIFFERENTIAE: LOUD AND CONFUSED.
TRY ANOTHER ANSWER.

Definition: Item 9:

DEFINITION IS CONSIDERED A MODE OF DEVELOPMENT IN COMPOSITION. AS SUCH, IT SHOULD NOT SERVE AS THE THESIS STATEMENT FOR AN ESSAY. DEFINITION PROPERLY BELONGS TO THE "MIDDLE" OR DEVELOPMENTAL SECTION OF AN ESSAY AS OPPOSED TO THE THESIS (OPENING) SECTION OR THE CONCLUSION. DEFINITION IS BEST USED TO CLARIFY UNUSUAL OR TRICKY WORDS OR WORDS THAT HAVE MANY POSSIBLE MEANINGS: IT IS ABUSED WHEN USED WITH ORDINARY AND FAMILIAR WORDS THAT REQUIRE NO CLARIFICATION. THE UNSOPHISTICATED WRITER BEGINS A PARAGRAPH WITH A DEFINITION. ON THE OTHER HAND, THE SOPHISTICATED WRITER FIRST EXTABLISHES WHY A DEFINITION IS NECESSARY: WITHOUT ONE, CONFUSION AND DISTORTION WOULD RESULT; HENCE, A DEFINITION SERVES THE TWO PURPOSES PREVIOUSLY MENTIONED: (1) A DEVELOPMENTAL DEVICE, (2) TO KEEP THE WRITER'S REASONING ACCURATE.

DEFINITION AS A MODE OF DEVELOPMENT IN COMPOSITION CAN CONSIST OF A SENTENCE, AN ENTIRE PARAGRAPH, OR, BY COMBINING THE VARIOUS TYPES

OF DEFINITIONS, AN ENTIRE ESSAY, A PARAGRAPH THAT OPENS WITH A DEFINITION INTENDED TO SERVE AS THE TOPIC SENTENCE IS RARELY AN EFFECTIVE PARAGRAPH. IT IS BETTER TO STATE THE TOPIC SENTENCE AND THEN DEFINE THE TERMS THAT MAY NOT BE CLEAR TO THE INTENDED AUDIENCE.
FOLLOWING ARE FIVE PARAGRAPHS. EACH CONTAINS A DEFINITION.
SELECT THE ONE PARAGRAPH THAT BEST UTILIZES DEFINITION AS A MODE OF DEVELOPMENT TO ENLARGE THE READER'S KNOWLEDGE.

1. THE BLIZZARD OF 1978 IN SOUTH BEND IS ONE I'LL NEVER FORGET. THE SNOW COVERED OUR WINDOWS AND WE COULDN'T EVEN OPEN OUR DOORS. NO TRAFFIC MOVED IN THE STREETS. I HAD EXPERIENCED SNOW STORMS BEFORE, BUT THIS WAS SOMETHING ELSE. A BLIZZARD IS A SEVERE SNOWSTORM WITH HIGH WINDS. WE HAD TO CRAWL THROUGH SNOW DRIFTS PULLING A SLED TO GET TO THE SUPERMARKET AND IT WAS A VERY COLD EXPERIENCE.
2. THE APPEARANCE OF THE RUSSIAN BALLET IN MY HOMETOWN WAS AN EXCITING EXPERIENCE. IT'S RATHER DIFFICULT TO DESCRIBE HOW IMPRESSIVE THE DANCERS WERE. A BALLET, BY THE WAY, IS AN INTRICATE GROUP DANCE USING PANTOMIME AND CONVENTIONAL MOVEMENTS TO TELL A STORY. THE COSTUMES WORN BY THE DANCERS WERE VERY DIFFERENT. I ENJOYED SEEING IT VERY MUCH.
3. PLAYING THE CLARINET, A SINGLE REED, WOODWIND INSTRUMENT, WITH A LONG WOODEN OR METAL TUBE AND A FLARING BELL, PLAYED BY MEANS OF COVERING HOLES OR DEPRESSING KEYS AND HAVING A MUSICAL RANGE OVER THREE OCTAVES, WAS DIFFICULT FOR ME WHEN I WAS IN THE NINTH GRADE. THE TEACHER WAS NOT PATIENT AND MY PARENTS FORCED ME TO PRACTICE WHEN I WANTED TO DO OTHER THINGS. THE RESULT TODAY IS THAT I HATE MUSIC.
4. WALKING THROUGH THE SWAMP, ALONE AND FRIGHTENED, I SOON OVERCAME MY APPREHENSION WHEN I WAS ABLE TO CONQUER MY FEAR AND CAREFULLY LOOK ABOUT. AROUND THE SWAMP, THE WET, SPONGY GROUND INTO WHICH

MY FEET SANK WITH EACH STEP, I SAW ALL KINDS OF STRANGE, SMALL INSECTS. THE VEGETATION, VERY DIFFERENT FROM THAT IN MY BACKYARD AT HOME, WAS ALL GREEN, BUT ADORNED WITH BLOSSOMS AND UNUSUAL SOUNDING INSECTS. STRANGE BIRDS FLEW ABOUT MAKING NOISES I HAD NEVER HEARD BEFORE, BUT WHEN I SAW THE ALLIGATOR'S TAIL, MY FEAR RETURNED.

5. THE TENNESSEE VALLEY AUTHORITY IS A FEDERAL CORPORATION ORGANIZED IN 1933 TO PROVIDE CHEAP ELECTRICAL POWER, FLOOD CONTROL, IMPROVED NAVIGATION AND IRRIGATION BY DEVELOPING THE POTENTIALITIES OF THE TENNESSEE RIVER AND ITS TRIBUTARIES. THE WORK WAS FIRST BEGUN AT WILSON DAM IN MUSCLE SHOALS. I THOUGHT IT WOULD BE A NICE PLACE FOR A FAMILY VACATION SINCE I COULD GET TO FISH IN THOSE WATERS. SURELY, SINCE THE AUTHORITY WAS CREATED IN 1933, THERE WOULD BE LOTS OF FISH THERE BY NOW.

QUESTION 9 RESPONSE 1

INCORRECT. THIS PARAGRAPH IS DEVELOPED BY THE DESCRIPTIVE PROCESS IN COMPOSITION AND THE DEFINITION OF A BLIZZARD AS THE FIFTH SENTENCE IN THE PARAGRAPH IS AN INTRUSION IN THE DESCRIPTIVE PROCESS WHICH RESUMES IN THE SIXTH SENTENCE. IT VIOLATES THE UNITY OF THE PARAGRAPH. TRY ANOTHER ANSWER.

QUESTION 9 RESPONSE 2

INCORRECT. THE DEFINITION OF BALLET IN THE THIRD SENTENCE OF THE PARAGRAPH APPEARS AS AN AFTER-THOUGHT AND IS EVEN SIGNALLED AS SUCH BY THE WRITER'S INTRODUCING THE PHRASE, "BY THE WAY." IT VIOLATES THE UNITY OF THE PARAGRAPH. TRY ANOTHER ANSWER.

QUESTION 9 RESPONSE 3
INCORRECT. THE DEFINITION OF "CLARINET" IS PLACED WITHIN THE FIRST SENTENCE AS A LONG, ADJECTIVAL CONSTRUCTION. PERHAPS IT WAS INTENDED BY THE WRITER TO SERVE AS ONE CAUSE OF THE EFFECT REPORTED IN THE FINAL SENTENCE. ALTHOUGH THE DEFINITION DOES ADVANCE THE READER'S KNOWLEDGE, ITS PLACEMENT AS A LONG, ADJECTIVAL CONSTRUCTION RETARDS THE PACE OF THE PARAGRAPH'S OPENING SENTENCE. TRY ANOTHER ANSWER.

QUESTION 9 RESPONSE 4
CORRECT. THIS PARAGRAPH IS DEVELOPED BY THE DESCRIPTIVE PROCESS OF COMPOSITION AND THE DEFINITION OF "SWAMP" IS SKILLFULLY WORKED INTO THE SECOND SENTENCE OF THE PARAGRAPH IN A MANNER THAT DOES NOT IMPEDE THE PARAGRAPH'S DEVELOPMENT NOR DESTROY ITS UNITY.

QUESTION 9 RESPONSE 5
INCORRECT. THE "LONG-WINDED" DEFINITION OF THE TENNESSEE VALLEY AUTHORITY CONTAINS ENOUGH INFORMATION TO SERVE AS THE THESIS STATEMENT FOR AN ENTIRE ESSAY. THE DEFINITION, THEN, AS A TOPIC SENTENCE IN A PARAGRAPH, IS TOO BROAD: IT LACKS PRECISION. TRY ANOTHER ANSWER.

The third and final excerpt consists of item 3 from the module "Purpose:"

THE THIRD CHARACTERISTIC OF WRITING WHICH LACKS A SENSE OF PURPOSE IS CALLED THE UNCRITICAL OR INSENSITIVE APPROACH. A WRITER IS INSENSITIVE WHEN HE OR SHE IGNORES THE DEMANDS PLACED UPON HIM OR HER BY THE AUDIENCE OR ASSIGNMENT. FOR EXAMPLE, INSTEAD OF LISTING THE CAUSES FOR A WAR AS REQUIRED IN A HISTORY COURSE ESSAY EXAMINATION, THE WRITER LISTS THE EFFECTS OF THAT WAR. A WRITER IS INSENSITIVE OR UNCRITICAL WHEN THE WRITING DOES NOT CARRY A LOGICAL SEQUENCE TO ITS CONCLUSION OR CONFUSES SEQUENCES OF EVENTS, FOR EXAMPLE:

BECAUSE BILL CUT HIS FINGER, IT RAINED TODAY.

SELECT THE ONE PARAGRAPH WHICH FOLLOWS THAT REVEALS UNCRITICAL OR INSENSITIVE WRITING. TYPE THE NUMBER THAT PRECEDES IT.

1. THE DOG WHICH WON FIRST PRIZE WAS TRULY DESERVING OF IT. WELL GROOMED AND WELL TRAINED, THE COLLIE HELD ITS HEAD IN PERFECT POSITION AS IT PERFORMED ALL THE REQUIRED COMMANDS. WHEN THE JUDGES CHECKED ITS TEETH AND PAWS, IT STOOD MOTIONLESS, LIKE A STATUE. WHEN THE DOG LEFT THE JUDGING AREA, IT MUST HAVE KNOWN THAT IT HAD PERFORMED WELL: ITS TAIL WAGGED MERRILY.

2. WHEN HE HEARD ABOUT THE ACCIDENT, WE ALL WERE SHAKEN BUT ALSO RELIEVED. WE HAD RIDDEN THAT AIRPLANE TO CHICAGO AND HAD SENSED NO DIFFICULTIES DURING THE FLIGHT. IT WAS A SHOCK TO HEAR THAT THE PLANE FELL INTO LAKE MICHIGAN WHEN IT LEFT CHICAGO FOR DETROIT. HOW LUCKY WE WERE TO DECIDE TO STOP IN CHICAGO BEFORE RESUMING OUR FLIGHT TO DETROIT.

3. WEARING EYE GLASSES, OR SPECTACLES AS THEY USED TO BE CALLED, SIMPLY CREATES SPECTACLES. I HAVE NEVER SEEN A PERSON WHO WEARS EYE GLASSES THAT LOOKED NICE. YOU WOULD THINK THAT WITH CONTACT LENSES AVAILABLE, PEOPLE WOULD NOT WANT THOSE FRAMES HANGING FROM THEIR EARS. THAT IS NOT WHY WE HAVE EARS.

4. BEFORE BEGINNING TO BAKE THE COOKIES, IT IS A GOOD IDEA TO ARRANGE ALL THE NECESSARY INGREDIENTS ON THE TABLE OR COUNTER. THEN FOLLOW THE DIRECTIONS VERY CAREFULLY. TOO MUCH SUGAR OR TOO LITTLE FLOUR MAY RESULT IN A TASTE FAR DIFFERENT FROM WHAT WAS EXPECTED. BE SURE TO OBSERVE THE OVEN TEMPERATURE CAREFULLY OR THE RESULT WILL BE BURNED OR UNDER-BAKED COOKIES.

5. WHEN PREPARING TO WRITE A RESPONSE FOR AN ESSAY EXAMINATION, ONE SHOULD FIRST BE SURE WHAT THE QUESTION REQUIRES ONE TO WRITE. ONE WAY TO DO THIS QUICKLY IS TO UNDERLINE THE NOUNS AND VERBS IN THE QUESTION AND EVEN TO ENCIRCLE THE PLURAL NOUNS. MAYBE IT IS JUST PSYCHOLOGICAL, BUT IT DOES HELP MOST WRITERS TO KEY THE RESPONSE TO THE QUESTION. OF COURSE, ONE MUST ALSO BE AWARE OF THE TIME LIMIT ASSIGNED TO THE QUESTION.

QUESTION 3 RESPONSE 1
INCORRECT. THE WRITING IS NOT UNCRITICAL. IT BEGINS WITH AN EFFECT, WINNING A PRIZE, AND THEN ENUMERATES AND DESCRIBES THE CAUSES OF THE EFFECT.

QUESTION 3 RESPONSE 2
INCORRECT. THE WRITER BEGINS WITH A CAUSE AND EFFECT RELATIONSHIP AND PROVIDES A LOGICAL SEQUENCE OF EVENTS. THE WRITING IS NOT, THEREFORE, UNCRITICAL.

QUESTION 3 RESPONSE 3
CORRECT. THE WRITING IS INSENSITIVE AND UNCRITICAL. FIRST, THE WRITER RISKS INSULTING THOSE PEOPLE WHO WEAR EYE GLASSES; SECONDLY, PEOPLE DO NOT WEAR EYE GLASSES SIMPLY BECAUSE THEY HAVE EARS. AS IS PROBABLY EVIDENT BY NOW, VIOLATIONS OF PURPOSE IN WRITING (DIRECTIONLESS, UNSELECTIVE, UNCRITICAL, OR INSENSITIVE) DO NOT OCCUR IN ISOLATION; THEY TEND TO OCCUR TOGETHER.

QUESTION 3 RESPONSE 4
INCORRECT. THE WRITING IS NOT UNCRITICAL; IT CAREFULLY DETAILS A LOGICAL SEQUENCE OF PROCESS ANALYSIS.

QUESTION 3 RESPONSE 5
INCORRECT. THE WRITING IS NOT UNCRITICAL; IT PRESENTS A PROCESS ANALYSIS OF LOGICAL SEQUENCE AND ADVICE.

A minimal amount of time is required to instruct a user how to access the review modules: on the average, about 10 to 15 minutes. The directions for responding to the questions or ending a session are the same for all modules and appear at the beginning of each module:

> THIS IS A COMPUTER REVIEW OF YOUR COURSE. ANSWER THE QUESTIONS WITH THE NUMBER OF THE CORRECT RESPONSE. ENTER THE NUMERAL 0 TO GET TO THE NEXT QUESTION, 99 TO SKIP A QUESTION, AND 100 TO END THE LESSON.

These review modules are somewhat like a programmed composition course or a composition workbook. The obvious advantage of the CAI approach lies in the instant response concerning the answer selected and the printed material which appears with the answer selected. Correct answers also contain reenforcement sections just in case the selection is the result of a guess. There are advantages for the course instructor as well: exercises neither have to be constructed and duplicated nor corrected.

An evaluation of the review modules will be administered at the close of the fall, 1979 and spring, 1980 semesters following their initial use in the Freshman Writing Programs at the University of Notre Dame.

Footnotes

[1] See, for example, E. B. Page and D. H. Paulus, The Analysis of Essays by Computer: Final Report. University of Connecticut, 1968; R. L. and N. Bishop, "Computer-Assisted Instruction in English Composition and Advanced Writing Skills," Information Processing, North-Holland Publishing Co., 1972, pp. 1041-45; R. L. Bishop, "An Evaluation of a Computer-Assisted Course in Writing," unpublished paper, University of Michigan, n.d.; E. A. Kline, "Computer-Assisted Review Exercises for English as a Second Language," Proceedings of the Fourth Annual Conference on Instructional Computing Applications, Bloomington, In., 1977, pp. 30-35; E. A. Kline, "Computer-Aided Review Lessons in English Grammar," Proceedings of the 16th Annual Convention of the Association for Educational Data Systems, Atlanta, Ga., 1978, pp. 165-69; R. E. Burns, W. I. Davisson, and E. A. Kline, "Computer Managed Tutorials at Notre Dame," Proceedings of the Fourth International Conference on Improving University Teaching, Aachen, Germany, 1978, pp. 1066-74.

[2] The author gratefully acknowledges the design of the computer programs by Professor William I. Davisson, Department of Economics, University of Notre Dame and editorial assistance in the programs' content by Catherine Flanagan, graduate student in history, University of Notre Dame.

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Thematic Information Text Revisions and Adjunct Questions

Researchers in education and psychology have attempted to improve comprehension and memory of texts by manipulating either features of texts (Anderson and Bower, 1973; Bransford and McCarrell, 1974; Kintsch, 1974) or by manipulating reader activities (Anderson and Biddel, 1975), Craik and Lockhart, 1972; Craik and Tulving, 1975; Frase, 1975; Rothkopf, 1972, 1976). There is a trend in research on comprehension and memory of prose texts (Crothers, Note 1, 1978, in press; Kintsch, 1977, 1978) to make use of explicit theories of text structure (van Dijk, 1973, 1976; Grimes, 1975; Halliday and Hasan, 1976). For instance, with regard to research on readability Kintsch and Vipond (1977) have pointed out the need for an adequate theory of semantic organization or macrostructure of passages. Anderson and Biddle (1975) noted that systematic ways of constructing adjunct questions was lacking. Not only can a linguistic theory of text structure be used to construct adjunct questions with precisely specifiable linguistic properties, but such theories can be used to modify stimulus texts in precisely specifiable ways.

The aim of the present paper is to investigate variables which can be manipulated to improve the efficiency of adjunct questions. The variables are text version (revised versus unrevised texts), conceptual level of adjunct questions (verbatim versus paraphrase answers) and thematic level of adjunct questions (thematic, non-thematic or irrelevant). Revisions of experimental texts were obtained from analyses of the texts carried out in accordance with Crothers' (Note 1) descriptive text linguistic theories. Adjunct questions were categorized into one of two possible conceptual levels. Either the adjunct questions require drawing of paraphrase inferences based on textual information, along with information supplied by the reader, or they can be answered primarily using verbatim material found in the text. Adjunct questions can be relevant to material which is thematic (central) or to material which is non-thematic (detail). Theoretical criteria for evaluating the thematic value of textual propositions are provided in Crothers (Note 1). Control adjunct questions are irrelevant to the specific content of the text, but address the same content area. This is a control for thematic value of adjunct questions and not for the efficacy of adjunct questions per se.

Text version is assumed to affect foremost the coherence of the revised texts. Linguistic coherence is assumed to be related to the ease with which readers can comprehend and remember what they have read. It is assumed that readers can more easily integrate linguistic material from a coherent text than from a text which is less coherent. Evidence that readers integrate linguistic material comes from the Bransford and Franks (1971) research. Subjects initially received short sentences. During later recognition testing subjects tended to recognize longer compounds which they had not seen during acquisition. Potts (1971) and Barclay (1973) gave subjects lists of sentences expressing pairwise relationships between objects which described a linear ordering of the objects. During recognition testing subjects were unable to distinguish acquisition sentences from novel sentences which correctly described the ordering. An interpretation of these results is that during acquisition subjects integrated the information contained in the separate sentences. Bransford and Johnson (1972) found that when the abstractness or novelty of the stimulus material prevented comprehension, possibly because subjects were unable to to represent or infer the relations expressed in the passages, later memory was poor. They found that activation of relevant knowledge by a title or picture before reading the passage improved comprehension and recall. Presentation of a title or picture after reading did little to facilitate comprehension or memory. An interpretation of this is that the processes involved operate during acquisition and are difficult to employ at a later time.

Kintsch (1977) has remarked that a prerequisite for comprehension is that the reader must be able to integrate the new information presented at any point in a text with old information already presented. The coherence of the reader's representation of the text depends upon this synthesis of information. In general the reader must draw various inferences to establish textual coherence. Haviland and Clark's (1974) demonstration of the given-new strategy shows this. Subjects locate the given information in a sentence, which corresponds with its presupposition, and use it as a pointer to a location in memory where new information is to be placed. Keenan and Kintsch's (in Kintsch, 1974) study of explicit and implicit propositions verifies that subjects do infer propositions during reading in order to connect explicitly sentences in a text in which the connection is not literally expressed. Bartlett (1932) found that subjects omitted peculiar details in recalling stories and provided settings and reasons for those not omitted. This can be interpreted as an illustration that the reader attempts to regularize content into a coherent pattern. Evidence for coherence relations at a global level comes from studies of macrostructure by Kintsch and van Dijk (1975) and Kintsch et al. (1975). One finding was that recall protocols were much more consistent across subjects if the subjects read a story with a familiar plot structure. If the plot structure was not familiar to the readers, for instance as in Apache indian myths, the protocols were much less consistent.

Several lines of research show that the semantic variable of thematic value, or variables closely related to it, such as ordination or perceived importance affects comprehension and memory of texts. Kintsch and Keenan (in Kintsch, 1974), Kintsch et al. (1975) and Meyer (1974) have shown that memory for superordinate propositions is superior to memory for subordinate propositions. In Meyer's experiment the ordination of a paragraph in the text structure was manipulated with the result that subjects remembered it better when it was superordinate than when it was subordinate. Thorndyke (1977) obliterated the structural ordination of a prose text by randomizing sentence order, and caused the levels effect to disappear. McKoon (1977) showed an effect of importance of propositions on the speed and accuracy of sentence verification. Johnson (1970) in an earlier study found that structural importance of verbal units was positively related to recall. Rothkopf and Billington (1975) have shown that telling subjects explicitly what is important (goal guidance) produces gains in memory performance.

There are several ways of looking at these results. Kintsch (1977) hypothesizes that superordinate propositions are implicitly processed more frequently, leading to better recall and recognition performance. On the other hand it may be that superordinate propositions are perceived as more important and subjects process them to a deeper level, in accordance with the Craik and Lockhart (1972) and Craik and Tulving (1975) levels of processing hypothesis.

The drawing of inferences while reading a text is assumed to affect the depth to which information is processed, and in turn the ease with which it can be recalled. Craik and Lockhart (1972) and Craik and Tulving (1975) have shown that the more deeply verbal information is processed the better it is remembered. Semantic processing produced higher levels of recall than did syntactic processing, which in turn was superior to processing of orthographic information. Again, Bransford and Franks (1971), Bransford and Johnson (1972), Bransford and McCarrel (1974), Barclay (1973) and Potts (1972) have shown that the inferences subjects draw or do not draw have an effect on level of recall.

The concept of theme used in this research is developed in the context of Crothers' theory of text structure. Roughly stated, a structural analysis produces a graph which makes explicit the component propositions of a passage and the connectives which link them. If two propositions are connected such that that one of them is an antecedent and the other a consequent, the consequent is considered thematic relative to the antecedent. An additional rule is that with relative clauses the main clause is thematic over the subclause. Given these rules and the graph of the underlying structure, Crothers (Note 1, pp. 73-74) proposes a relatively automatic system of coding the connectives and producing a thematic index for each terminal node (and associated proposition) of the graph. Given this method of analysis theme is not an all or none affair, but a matter of degree. The propositions of a well written text have thematic values reflecting a range from incidental detail to broad themes.

Experimental hypotheses follow. Groups receiving thematic adjunct questions should attain higher average criterion test scores than groups receiving non-thematic questions, and groups receiving irrelevant questions should score lowest. This is assumed to be the result of differences in rehearsal processes induced by the different experimental conditions. If the readers expect non-thematic questions they should tend to rehearse material with low thematic value. This material tends to be subordinate in the text. If readers expect thematic adjunct questions they should tend to rehearse thematic material which tends to be superordinate in the text. Comprehension and memory of superordinate information should aid in integrating subordinate propositions. This would not be the case for rehearsal of subordinate information. The more integrated and stable the representation the higher the average test score ought to be. By contrast, groups receiving irrelevant adjunct questions do not need to rehearse textual material to answer those questions. For these groups a relatively poorly integrated and unstable representation ought to be the result, which should be associated with correspondingly poor performance on the test. Reading times should correspond to the amount of rehearsal, with groups receiving thematic questions taking the longest and those receiving irrelevant questions taking the shortest amount of time.

Groups receiving paraphrase adjunct questions ought to perform better on the criterion test than groups receiving verbatim adjunct questions. It is assumed that answering verbatim questions requires reconstruction of relatively superficial lexical information, while paraphrase adjunct questions require a more elaborate semantic reconstruction of the text. Semantic reconstruction is hypothesized to result in a more integrated and stable representation than lexical reconstruction. Thus answering paraphrase adjunct questions ought to be mnemonically more efficient than answering verbatim adjunct questions. With regard to reading times answering paraphrase adjunct questions ought to induce more extensive initial processing than answering verbatim adjunct questions. Thus groups in the former condition should have longer reading times than groups in the latter condition.

Revised texts ought to be more coherent than unrevised texts, facilitating the integration of textual information. With unrevised texts certain propositions, relations between propositions and arguments of propositions may be left implicit. If the reading task does not call for much inferential processing these inferences may not be drawn. By contrast, use of the revised text should result in a more coherent and hence more memorable representation of the text. Thus groups reading revised passages should have larger average criterion test scores than groups reading unrevised passages.

Method

Subjects. One hundred and eighty students from introductory psychology courses served as subjects in partial fulfillment of course requirements. Fifteen subjects were randomly assigned to each of the twelve cells of the experimental design.

Materials. Titled passages taken from Scientific American articles were used. The experimental passage, entitled The 1976 Nobel Prize in Medicine, was 433 words in length in the original version and 530 words in length in the revised version. The revised version of the passage was obtained by analyzing the original by Crothers' methods, and editing it in accordance with the outcome. Information about the thematic value of the component propositions of the passage was obtained from the analysis. An adumbration of Crothers' analysis procedure follows.

The application of the theory produces a detailed, rigorous description of the text's structure, especially its coherence and degree of explicitness though other features (e.g. metaphors, lexical, relations) are noted as well. When applying the theory with the goal of producing a clarifying revision, the aim is to revise the structure, but not the content, of the passage. Unfortunately the structure description by itself is not accompanied by an algorithm for producing revisions. Since lapses in text cohesion presumably retard comprehension, a major aim of the revising is to augment the cohesion. Upon detailed analysis of the text it usually turns out that numerous specific types of revisions for increasing the cohesion are suggested. In the present study a "shotgun" approach was adopted, incorporating a wide variety of such revisions rather than only those of one particular type. Overall, the revisions tend to yield a lengthier, more explicit, and more structured text. For the Nobel Prize passage, the main kinds of revisions made are as follows: redundant phrases and clauses may be inserted to increase the coherence of the text; thematic conclusions may be inserted at the outset of the appropriate text section; material may be inserted to explicate implicit contrasts; implicit propositional links may be inserted in an argumentative text or causal description; likewise implicit connectives may be inserted; sentence order may be permuted to clarify relationships which are not obvious; definitions of obscure terms may be supplied; and sentences which appear to be tangential in terms of the analysis may be deleted.

Adjunct questions and criterion test questions had the same short answer format and underwent the same development. Care was taken that they be comparable in all respects possible. Adjunct questions were all short answer, requiring one word, or in a few cases two word answers. Questions were categorized as either thematic, non-thematic, or irrelevant. Questions irrelevant to the text, provided as a control, did not refer to information in the texts but rather accessed information in the same general content universe. For example, irrelevant questions for the Nobel Prize passage addressed themselves to matters of common knowledge about the Nobel prize, about medical practice of doctors, and about the countries which were mentioned in the passage. Thematic questions referred to propositions with relatively high thematic values in both the original and the revised versions of the texts. Non-thematic adjunct questions referred to propositions with relatively low thematic values.

Questions could be based either on the verbatim text or could require a paraphrase inference in order to be answered. Text-relevant verbatim questions could be answered on the basis of information which was explicit in the text. Text-relevant inference questions were answerable on the basis of information supplied by the subject about the content universe in combination with information explicit in the text. Answers to verbatim questions were names, dates and figures. Usually verbatim questions contained lexical items repeated verbatim from the text which were intended to help in locating information relevant to the answer. Usually paraphrase questions required conceptual kinds of answers. These questions were phrased such that some processing beyond that required for a verbatim question would be needed to comprehend the question and locate the information in the text relevant to the answer. Text irrelevant verbatim questions were constructed by the experimenter such that answering them required less processing than did answering text-irrelevant inference questions. Combining the categories factorially, six distinct types of questions resulted: thematic inference; thematic verbatim; non-thematic inference; non-thematic verbatim; irrelevant inference; and irrelevant verbatim.

The lists of questions underwent two stages of refinement. Initially, large pools of the four categories of text-relevant questions were generated. In a first pilot study subjects were given the lists of questions and the experimental passage. The passage was available for reference at all times. Subjects were asked to answer the questions and evaluate them with regard to clearness. The criteria for including the questions in each category were explained to the subjects, and they were asked to indicate those questions which seemed most typical of the categories. On the basis of the outcome of the pilot study questions which were unclear or were left unanswered by more than two of the seventeen subjects in the pilot study were discarded, or were reworded if the flaw in the item could be identified and corrected. Questions which were least typical of the categories were discarded.

A second pilot study controlled for the possibility of transfer of information from old to new items on the criterion test. In each of the four categories of text-relevant questions a subset was identified which contained candidate adjunct questions. Subjects were given the lists of questions with the answers to the candidate adjunct questions filled in. Subjects were instructed to attempt to provide answers to the unanswered items on the basis of the given information. Any question which showed signs of being answerable on this basis was discarded, or was modified if the source of the answer could be identified and made ineffective.

Each of the four categories of text relevant questions contained ten questions, five of which were included in the text as adjunct questions. Unfortunately it was not practical to randomly select the set of five adjunct questions independently for each subject. Adjunct questions were selected so they could be spread over the body of the text as evenly as possible. For the warm-up passage each of the six categories contained two questions, both of which were included in the text. Pilot studies were not run for the warm-up passage questions, although care was taken that they be comparable to the experimental passage questions. In both the presentation of the warm-up and the experimental passage the adjunct questions immediately followed the presentation of the relevant text propositions. Irrelevant questions were distributed evenly through the text. The order of the questions on the criterion test followed the order of the presentation of information in the text. Text-irrelevant questions were not included in the criterion test.

The criterion test contained 40 questions. Half the questions were thematic and half were non-thematic. Half required paraphrase inferences and half could be answered on the verbatim text. For each subject five of the questions were repeated and the rest were new.

Apparatus. Presentation of instructions, texts and adjunct questions was controlled by a Xerox Sigma 3 computer at the Computer Laboratory for Instruction and Psychological Research (CLIPR) at the University of Colorado. Experimental materials were presented on the screen of a IV/70 Fourphase Systems keyboard-display unit. The sequence of experimental events was programmed using the Display Terminal Experiment System (DTES), which is operational on the computer (Spear, Note 2). Below and to the front of the screen was a response box, with buttons, on which responses were made by the subject. At any time during the course of the experiment the subject was able to summon the experimenter by means of a call button. Two such experimental set-ups were available in each of three rooms, making it possible to run from one to six subjects at at time.

Design. A design with three between-subjects factors (BS) was used: version, including unrevised (UBS) and revised (RBS) versions of the text; theme, including thematic (+TBS), non-thematic (-TBS), and irrelevant (IBS) adjunct questions; and verbatim versus paraphrase, including verbatim (VBS) and paraphrase (PBS) adjunct questions. Times to read the individual sentences (RT) were recorded and summed to obtain a total reading time for each subject. Total reading times did not include time used to answer adjunct questions. These were analyzed with the total text scores (TTS) using the between-subjects factors as independent variates.

Procedure. A brief introduction to the use of the keyboard-display units and button boxes was given to each subject. Thereafter instructions and materials were presented by the Display Terminal Experiment System (DTES). Subjects were instructed how to respond on the button box and made aware that they would be tested on what they read. If a question seemed difficult subjects were instructed to supply the best answer they could and go on. Following the instructions, sentences of the warm-up and experimental passage were presented one at a time on the display screen. Subjects proceeded at their own pace, pushing a button on the response box to see the next sentence or adjunct question. At appropriate places adjunct questions appeared on the screen. The subjects wrote down their best answer on an answer sheet and pressed the response button to go on. Error rates on these questions were extremely low, so these data were not analyzed. Each subject read and answered five questions interspersed throughout the text. Reading latencies from the onset of a screen to the next button push were recorded by the computer. Upon finishing the experimental passage each subject was given a booklet containing the criterion test. Directions for the test were as follows: "Please answer the questions with one or two words. If a question seems difficult write the best answer you can think of and go on to the next one." The experimental session ended after finishing the criterion test. Average duration of the experimental session was 35 minutes.

Results

The MANOVA in Table 1 revealed the main effect of theme to be significant, $F(6,332) = 2.68$, $p < .05$. The stepdown F ANOVA for total score in Table 2 was significant, $F(2,168) = 2.28$, $p < .05$. Referring to Table 3 of cell means and condition averages, the mean number of correct responses for all groups receiving thematic adjunct questions was 21.28, compared with 19.62 for non-thematic adjunct questions. However, the contrast of average total test scores between groups receiving thematic and non-thematic adjunct questions was not significant.

Insert Tables 1, 2 and 3 about here

The overall score of groups receiving thematic adjunct questions was 21.28 correct, compared to 17.78 correct for those receiving irrelevant adjunct questions. Examination of the contrast between total test scores for these groups revealed a significant advantage for subjects in the thematic condition, $t = 3.02$, $p < .05$.

Examination of the stepdown F tests for theme revealed a significant effect for the reading time dependent variate, $F(2,167) = 3.42$, $p < .05$. Consideration of reading times in Table 3 revealed that the average reading time for groups receiving thematic adjunct questions was 14.29 minutes, compared with 12.08 minutes for groups in the irrelevant condition. The contrast of reading times between these two groups was significant, $t = 2.68$, $p < .01$. Groups receiving thematic adjunct questions required 14.29 minutes on the average to read the passage, compared to 12.15 minutes for groups receiving non-thematic adjunct questions. The contrast of average reading times for these groups was significant, $t = 2.61$, $p < .01$.

The main effect for version in MANOVA Table 1 was significant, $F(2,167) = 21.14$, $p < .001$. Consideration of the stepdown F values in Table 3 revealed a non-significant value for the total score dependent variate, and a significant one, $F(1,167) = 41.45$, $p < .001$, for the reading time dependent variate. Turning to the mean reading times in Table 2, it was seen that the mean reading time for groups receiving the revised passage was 14.93 minutes, compared to a mean reading time of 10.74 minutes for groups receiving unrevised texts. Although the MANOVA showed a significant main effect for version, this was attributable to reading time differences. Average reading rate for the unrevised passage was 40.32 words per minute compared to 35.50 words per minute for the revised passage. This reflects a change of 11.96 percent in reading rate which is not accounted for by the increased length of the revised passage.

Discussion

Little support was found for the hypothesis that groups receiving thematic adjunct questions score better than groups receiving non-thematic adjunct questions. By contrast, significant differences in scores were found between groups receiving thematic questions and those receiving irrelevant control questions. Significant differences in reading times were found both for the contrast between groups receiving thematic and non-thematic adjunct questions, and for groups receiving thematic compared with groups receiving irrelevant adjunct questions. Higher test scores for groups receiving text relevant questions could be accounted for in terms of increased rehearsal of textual material by contrast with less rehearsal for groups in the irrelevant condition. Increased rehearsal might account for the longer reading times of groups receiving text relevant adjunct questions. Even though the difference in scores for groups receiving thematic and non-thematic adjunct questions was not significant the results were orderly in the sense that those receiving non-thematic questions had scores intermediate between the other two groups. The test score results are consistent with the reading time results in that one would expect higher test scores to be associated with longer reading times.

The results did not support the hypothesis that groups receiving paraphrase adjunct questions would score higher on the average than groups receiving paraphrase questions. This unexpected result could be explained by distinguishing between immediate and delayed testing as follows. For short intervals following presentation of the text memory for verbatim information is assumed to be as good as memory for inferred and semantically deeper information, in accordance with Craik and Lockhart (1972) and Craik and Tulving (1975). At this time groups receiving verbatim adjunct questions should have the advantage, since they studied verbatim information. Memory for superficial verbatim information is assumed to decay faster than memory for semantically deeper information. After a suitable delay groups receiving verbatim adjunct questions should no longer have the advantage. Groups receiving paraphrase adjunct questions should now perform better for their questions directed their attention to semantically deeper information.

With regard to version it had been predicted that the revised passages would be easier to encode and that their representations would be more coherent than those of unrevised passages. Bearing in mind that the main effect for version is attributable to reading time differences, there is little support for this hypothesis. The reading time differences themselves are partly explained by the greater number of words in the revised as compared to the unrevised version. But the differences could not be accounted for completely in terms of length. Possibly the spelling out of originally implicit inferences, the explication of important material and the deletion of less important material, which were involved in producing the revision, are responsible for this change in reading rate. Rothkopf (1976) predicted that manipulation of materials would have little effect on measures of comprehension and memory compared to the effects of manipulation of processing activities. This prediction appears to be confirmed by the lack of a main effect of version on test scores.

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Table 1

MANOVA for Test Scores and Reading Times

Source of Variation	Degrees of Freedom	Estimated F
Theme (T)	(6,332)	2.68*
Verbatim-Para. (C)	(2,167)	.63
Version (V)	(2,167)	21.14***
T x V	(6,332)	.15
V x C	(2,167)	.64
T x C	(6,332)	.74
T x C x V	(6,332)	.26

MANOVA summary for total test score and reading time. Hotelling's F is reported. Interpretation of the asterisks is as follows: * = significant at the .05 level; ** = significant at the .01 level; and *** = significant at the .001 level.

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Table 2

Stepdown F Tests for Total Test Scores and Reading Times

Source of Variation	Dependent Variate	Degrees of Freedom	F Ratio
Theme (T)	Total	(2,168)	4.58*
	Time	(2,167)	3.42*
Verbatim-Para. (C)	Total	(1,168)	.78
	Time	(1,167)	.49
Version (V)	Total	(1,168)	.66
	Time	(1,167)	41.45***
T x V	Total	(2,168)	.36
	Time	(2,167)	.09
T x C	Total	(2,168)	1.48
	Time	(2,167)	.76
V x C	Total	(1,168)	.03
	Time	(1,167)	1.26
T x V x C	Total	(2,168)	.15
	Time	(2,167)	.63

Stepdown F tests associated with the MANOVA of Table 1. Interpretation of the asterisks is as follows: * = significant at the .05 level; ** = significant at the .01 level; *** = significant at the .001 level.

Table 3

Cell Means and Condition Averages for Test Scores and Reading Times

Total Test Score Cell Means

	+TBS		-TBS		IBS	
	RBS	UBS	RBS	UBS	RBS	UBS
VBS	22.20	23.00	17.73	20.20	18.60	18.13
PBS	20.06	19.86	19.60	20.93	16.86	17.53

Total Test Score Condition Averages

+TBS = 21.28
-TBS = 19.62
IBS = 17.78

RBS = 19.17
UBS = 19.94

VBS = 19.97
PBS = 19.14

Reading Time Cell Means

	+TBS		-TBS		IBS	
	RBS	UBS	RBS	UBS	RBS	UBS
VBS	16.64	13.87	14.03	10.04	13.84	10.29
PBS	16.54	10.12	14.32	10.20	14.26	9.94

Reading Time Condition Averages

+TBS = 14.29
-TBS = 12.15
IBS = 12.08

RBS = 14.93
UBS = 10.74

VBS = 13.1
PBS = 12.5

Cell means and condition averages for total test score and reading time broken down by levels of theme (+TBS, -TBS, IBS), verbatim-paraphrase (VBS, PBS) and version (UBS, RBS). Test scores are reported as number correct. Reading times are reported in minutes.

SPI for SPSS

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Introduction

These days we are confronted with a plethora of initials and acronyms, and the computer industry is probably as responsible for the situation as any. To take just this Conference, for example, we are bombarded with, among other letters, CAI, CMI and CBE. One would think that enough is enough. The idea is appealing, but alas, untrue, for this paper uses still another term. The SPI of "SPI for SPSS" stands for self-paced instruction. We will attempt to explain how the principle of self-paced instruction has been used in the development of a set of interactive teaching modules which are intended to enable the uninitiated to become an independent user of SPSS.[1]

SPI is similar to but in many important respects different from the better known PSI, Keller's Personalized System of Instruction.[2] We can explain the Keller Plan as one which individualizes instruction through allowing the student to control the learning pace, requires unit mastery before proceeding, uses the classroom as a secondary rather than primary teaching medium, stresses written teacher-student communication, and utilizes proctors for grading and tutoring. The Plan includes well-defined objectives for each unit, frequent testing and feedback, and human interaction. Most of the research comparing variates of the Keller Plan with variates of the lecture-discussion method of teaching have shown the former to produce superior academic achievement and retention as well as more positive attitudes toward the learning process.[3]

The main differences between SPI and PSI are the facts that the computer replaces the proctor for tutorial purposes and that the notion of student pacing is more strongly emphasized. The ideas of unitized materials, well-defined objectives, written communication and frequent testing and feedback remain the same. Although unit mastery is not required before a student is allowed to proceed through the SPI for SPSS modules, failure to master earlier material will in fact lead to incomprehension of later modules. This will necessitate retaking the previous materials until they are mastered.

Before describing some of the principles of self-paced instruction which are illustrated in the modules, I should call attention to the fact that they are written in Multitutor, a computer based educational approach which was originally developed at Northwestern and has since been installed at other computer systems throughout the country. Multitutor utilizes many features of the PLATO IV language, Tutor, but requires only conventional terminals to author and execute CAI lessons. Multitutor has the capability both to link one CAI lesson to all or parts of another and to link a CAI lesson to other languages and programs on the system. For example, within Multitutor the user can be led from a Multitutor lesson to a Fortran program and back again to the CAI lesson.

There are 12 SPI for SPSS lessons in all, and they have been written on a Control Data Corporation Cyber 72-14, which is the central processing unit of the Mid-Illinois Computer Cooperative. MICC was formed in 1974 and is now comprised of ten state universities throughout Illinois, each of which can lease to other institutions.

Self-Pacing

As self-pacing may mean different things to different people, I want to clarify how the term is being used. It is being used in the sense that the student has significant control over important aspects of the speed with which s/he is presented with and expected to absorb the learning materials. It does not mean that the learning process is under the total control of the student. That would run the risk of procrastination and no acquisition of skills and understanding.[4] It is expected that such tendencies would be offset by instructors establishing deadlines for assignments and of course the incentive of better grades for assignment completion.

Beginning with a self-evident point, the student controls his/her learning pace through controlling the carriage return. Students can thereby do anything from skimming the materials to carefully reading them several times before asking for more.

The student, interacting with the computer, also controls his/her learning pace through answers to the multiple-choice questions which are asked throughout. This is done in several ways. A wrong answer is sometimes used to pinpoint a problem and clarify the misunderstanding which the answer has denoted. An answer occasionally leads to the student's being taken back to an earlier lesson which has been improperly understood or an earlier assignment which has not been completed. The number of correct answers to a series of questions can determine whether the student is taken to a review unit within a module or allowed to continue his/her linear progress through the module.

A related topic of self-pacing is the student's frequent option to skip non-essential segments of a module. In the first module, for example, s/he may forego more details about logging on, and the student interested only in interactive mode may opt not to take the sections concerned with batch mode. Similarly, a mini-lecture about statistical choice may be ignored.

The learner, furthermore, has choices of reviewing a particular unit or units of a module, thereby controlling the number of times s/he is exposed to the material. Faster learners will not have to review, and slower learners are able to proceed at a private pace consistent with their needs. And as stated above, people who have inadequate mastery of the early modules will be forced by their inability to comprehend later ones to retake early lessons in their entirety.

When a particular module becomes too difficult or boring, the student is given ways of immediately exiting the lesson. On the other hand, when the material is rather easy, the student has opportunity to take two or more lessons in a row before logging off the terminal.

A less obvious but more important way self-paced instruction is implemented in the modules is that the student often controls the order of presentation. The facts that certain segments of the modules can be skipped and that the student has control of what (if anything) is to be reviewed have already been mentioned. Another example would be the module which discusses batch SPSS, where the student is given the choice of initially studying either the necessary program commands or the necessary system commands. Again, the student does not have total control, for the author assures that the basics are covered, and covered incrementally. But where the order of presentation is not essential to the learning process, authority is turned over to the student.

Perhaps the most important way a combination of author-paced and self-paced instruction is reflected by the modules is the principle of incrementally increasing difficulty. Beyond that, the early modules use a stimulous-response approach with maximum possible reenforcement, whereas the later modules increasingly emphasize student initiative and independence. As the student obtains the actual outputs of frequencies tables, cross-tabulations, product-moment correlations, partial correlation, analysis of variance, regression, and discriminant analysis runs, substantive and theoretical implications are discussed and, most importantly, questions for additional thought and analyses are suggested. The student is steadily given an increasing amount of ability, freedom and encouragement to perform his/her own data analyses. This can be done not only within the modules but also independently of the modules through using the SPSS system file to which the modules are linked. The modules are thus intended to lead the student, at his/her own pace, from a state of relatively passive learning to a state of relatively active inquiry.[5]

The extent to which s/he can carry this inquiry is far-reaching. Having begun with questions suggested but not examined in the modules, the student can use the same data base to examine research questions not even suggested in the text. Less than half of the 26 variables which constitute the illustrative data base are seriously considered in the modules themselves. Similarly, the student is free to go to the pages referenced in the SPSS manual for more details about most topics covered in the modules. It all depends on his/her interests and abilities, and the requirements of the instructor.

Having learned a set of basics about his/her terminal, the system's files and commands, SPSS's data definition, transformation and selection statements, an SPSS system file, and, most importantly, performed and interpreted a variety of statistical tasks, the student should come away as a self-sufficient user of SPSS. If the intended results are achieved, and preliminary evidence indicates that this is so, the SPI for SPSS modules will have taught a useful societal skill in an individualized manner. In other words, they will have given the novice some familiarity with computers and some skills in statistical analysis, and they will have done so at a pace with which his/her ability and personality are comfortable.

Content

This paper will conclude, albeit anti-climatically, with a brief description of the substantive content of the 12 modules. TS1 is simply a general introduction to interactive terminals, the computer, and overcoming one's anxieties about dealing with such machines. TS2 introduces the student to the Mid-Illinois Computer Cooperative, discussing important distinctions among three categories of files and two categories of commands and finally illustrating the use of specific system commands. (TS2A can be taken as a short-cut to reviewing particular sections of TS2.) Still discussing the system per se, TS3 instructs the student in creating and storing data files, both interactively and through the card reader. The student is also assigned the task of creating his/her own small data file.

The discussion of SPSS begins in TS4, where required data definition statements are presented and the student is taught how to do a small run on his/her previously created file. TS5 introduces some more sophistication and flexibility to required data definition statements, introduces a way of getting statistics from SPSS, and explains how procedural files can be kept for later use.

Although the modules concentrate primarily on interactive SPSS, TS6 is devoted to a presentation of batch SPSS. Here the necessary cards for doing an SPSS run via the card reader are presented, and the minor differences between interactive and batch program commands are illustrated.

The gloves begin to come off in TS7, where the student is presented with a Codebook of our illustrative data file, a DATA LIST statement is detailed, and the handling of missing data is discussed. The data used in modules seven through 12, by the way, are taken from the Center for Political Studies' 1976 National Election Study.

TS8 descusses and illustrates additional optional data definiton statements, explains what an SPSS system file is, and takes the student through the process of creating one. In TS9 the student obtains his/her own frequency distributions and cross-tabulations, is given the opportunity to read a mini-lecture on statistical choice, is exposed to a method of reducing response time through sampling the data, and is introduced to data transformation statements. (TS9A can be taken as a short-cut to the mini-lecture.)

TS10 introduces and for the most part illustrates, through the student's typing the necessary commands, Pearson correlation, partial correlation, and several ways of comparing means (T-TEST, BREAKDOWN, ANOVA). Additional data transformation statements are also presented, discussed and implemented. (TS10A can be used as a short-cut to a limited review of some of the topics discussed in TS10.)

TS11 deals with data selection, analysis of variance, regression analysis and factor analysis. TS12, finally, is concerned with path analysis and discriminant analysis, concluding with some words of caution and humility.

NOTES

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2. Keller, 1967, 1968; Sherman, 1974.

3. A good summary of such research can be found in Robin, 1976.

4. See, for example, Keller, 1968 and Hess, 1974.

5. This is similar to the generative approach discussed by Kearsley, 1977, p. 13.

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GROUP PROBLEM-SOLVING WITH AUTOMATIC MEDIATION

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The goal of this research (Stodolsky, 1976) was to test a method of balancing participation in group problem-solving. Balancing participation is important because much of our time is spent in groups, and participation affects the quality of group interaction. It has been hypothesized that increased vocal participation by low initiators focuses their attention, reduces their anxiety, improves their self-confidence, and increases their benefits from interaction in both the therapeutic and educational settings (Aiken, 1965; Gilmore, 1968; Jorgenson, 1973; Sechrest & Berger, 1961). Inadequate participation is associated with speech anxiety, lack of assertiveness, and inattention (Wine, 1973). Even without barriers to balanced group participation such as social dominance behavior, speaker anxiety, inattention, and boredom, the dynamics and complexity of coordination and control in group discussion may preclude such balance.

A major objective of this research was to balance vocal participation without an explicit leader, thus avoiding potential problems of this role. In parliamentary procedure, for instance, a skillful chairperson, in coordination with a supporting coalition, can preempt the opposition's right to speak. With an automatic mediation system, the distribution of speaking turns is less dependent upon the parliamentary skills of a chairperson or an individual contesting for a turn. With automatic mediation the rules of conflict resolution may be directly implemented, and the system may aid the unskilled individual in gaining an opportunity to speak.

In the research reported here, an automatic mechanism for resolving conflicting requests to speak was demonstrated in an experiment requiring the learning of complex problem-solving strategies. After reviewing some advantages of automatic mediation in group problem-solving, a more detailed description of this experiment is presented. Finally, some of the experimental results are reported and discussed.

Many techniques for group problem-solving specify rules for allocation of turns and time limits to speakers. Most of these require a chairperson who is responsible for the proper application of these rules. In large groups the obvious need for a mechanism of interactional coordination which balances participation led to the development of Robert's Rules of Order (Robert, 1967), introduced in 1876. Robert's rules attempt to separate coordination of group interaction from control of group interaction. Despite these aims, Robert's rules give the chairperson considerable discretion, and therefore considerable control over the group. Thus the chairperson, limited by the degree of group support, has the crucial role in guaranteeing proper application of the rules and opportunity of all group members to speak.

An automatic mediator, by contrast, gives each person an equal degree of control over the speaker selection process and equal responsibility for invocation of the agreed upon rule(s). This is achieved by combining anonymous inputs using automatic rules which publicize the result. An anonymous communication channel transmits speech request signals to the mediator. The automatic mediator uses these signals to select the next speaker according to specific rules.

In the telephone conferencing experiment reported here, a computer mediator collected speech request signals and then publicly displayed the new speaker's name while simultaneously activating that person's microphone. The automated experiment incorporated a logical task for objective evaluation of different speaker selection rules.

In the Conference Call experiment, an operational model both controlled the course of events in an experiment in group problem-solving and moderated ongoing discussion among group members. Once the names of the participants were typed into the control terminal by the experimenter, only the system interacted with the participants until the experiment terminated; that is, the experimenter did not intervene once the experimental session was initiated. Lack of intervention reduced experimenter bias and freed the experimenter for other activities. In the Conference Call experiment, the computer presented instructions, mediated a get-acquainted conversation, assigned names to booths, presented the problem, mediated discussion, called a special discussion period if procedural errors were made repeatedly, accepted responses, recorded detailed data on its own behavior as well as on that of the participants, and finally terminated the experiment by asking participants to report to a room for debriefing. Pool and Grofman (1975) discuss the advantages and disadvantages of using computer models to administer experimental games. They consider using the computer to 1) simulate subjects, 2) organize experimental games and 3) analyze data.

Two algorithms or rules for speaker selection were compared in the Conference Call experiment. In first-in first-out conferencing (FIFO), the machine mediator placed the group members' names on a list of people waiting to speak when they pressed their buttons. When the previous speaker finished, the mediator selected the first person still on the list, that is, the one who had been waiting the longest to speak. In equal time conferencing (EQTM), the mediator placed the group members' names on a list of people waiting to speak when they pressed their buttons. When the previous speaker finished, the mediator selected the person still on the list who had spoken the least.

The preliminary hypothesis concerning participation was that the equal time resolution rule would balance vocal participation more effectively than the first-in first-out resolution rule. Two methods of determining the relative balancing effects of these rules are discussed in Stodolsky (1978). The first is comparison across experimental conditions. The second is simulated comparison; during data analysis of one speaker selection algorithm, the other is simulated. Thus at each point a speaker was selected, the data analysis program determined whether the simulated algorithm would have resolved the conflicting floor requests differently. This differential resolution measure indicated to what degree the different algorithms chose the next speaker differently. Preliminary results indicate that alternative conflict resolution rules can strongly influence speaker order in groups as small as four persons (Stodolsky, 1978).

In the analysis to be presented here, the assumption that unresolved transitions in automatically mediated conferences are equivalent to free discussion is examined. The initiation rates are compared to those predicted by Horvath's (1965) turn-taking model. Unresolved transitions in this experiment follow the first-in first-out rule; when no requests were pending, the first requestor was immediately granted a turn. Then the effect of transfers of turns to low participators by the equal time resolution rule is examined by comparison with the same theoretical model.

The first order speaker-to-speaker transitions are presented in Table 1. The number of times a speaker initiated conversational interaction is given by the top row. For instance, Tara-Nata followed the mediator (number 0) 90 times during the session. This same speaker terminated a conversation, that is, was followed by the mediator, 79 times. All terminations are given in the first column. The diagonal of the table indicates the number of times a speaker took two or more turns in a row. None did so in this group. The mediator did follow itself 12 times. This can only occur as an interconference event. Thus 12 times in the session the mediator terminated a conference and began the next one. The number of times any speaker followed any other can also be read from the table. For instance, Kathryn followed Cliff nine times during the experimental session.

According to Table 1, a vast majority of the transitions occurring in the session were either to or from the mediator. Since the transition to the mediator can occur only if there are no requests pending, no conflicts can occur during such transitions. Also, because of the 1/10 of a second cycle time used by the mediator, it is unlikely that there would be any conflict upon transitions from the mediator. In this sense, both speaker selection algorithms would be considered FIFO selection algorithms; either one will take the first person who requests the floor. Thus the speaker selection algorithms are different only secondarily, one being FIFO-FIFO and the other FIFO-EQTM. The effective difference between them could be increased by permitting floor requests to cumulate over a period longer than 1/10 of a second while waiting. In some groups, participants reported using the display "Waiting for new speaker" to indicate that the previous speaker had terminated. This behavior would account for the large numbers in the first row and column of the transition matrix, and for the small number of total conflicts.

Table 2 presents number of turns initiated from the waiting state (first row in transition matrix) during conferencing for four groups. The fit to Horvath's (1965) model assumes each person has the same constant probability, P, of initiating the next comment. It is further assumed, however, that the group rapidly reaches a hierarchical equilibrium such that members wait for the persons preceding them in the hierarchy to speak.

Thus, the proportion of turns taken by the highest participator is represented as P; the second person speaks with a probability $(1-P)P$; the third $(1-P)^2P$, the nth $(1-P)^{N-1}P$. If no one down the hierarchy speaks, then the highest participator gets another chance. The probability of the first ranking person speaking is the sum of probabilities from each chance $P + P(1-P)^N + P(1-P)^{2N} + \ldots$. The sum of the infinite series is:

$$\frac{P}{1-(1-P)^N}$$

This is equivalent to A, the fitted proportion of initiations by the highest participator in the Stephan and Mishler (1952) equation. The second ranked person's probability becomes $A(1-P)$, the third $A(1-P)^2$, etc. If $(1-P)$ is replaced by r, $A = (1-r)/(1-r^n)$ and proportion of turns taken by $i = Ar^{i-1}$. Thus, a single parameter P, the probability of initiating the next comment, can be used to deduce the Stephan and Mishler equation.

The fit to the FIFO data in Table 2 is good ($X^2 = 5.46$, 2df, non-significant). The predicted initiation rates are all derived from the totals, where the mean P is .39. Table 3 gives the number of equal time (EQTM) resolutions for each group and the combined (FIFO + EQTM) for each group. The attempt to fit the combined totals with $P = .39$ fails ($X^2 = 9.25$, 3df, p .05). The more conservative approach of fitting the combined totals with their own $P = .30$ also fails ($X^2 = 7.72$, 2df, p .025). The predicted for each group are computed with this P. The intervention of the equal time resolution rule has the effect of reducing the apparent initiation probability by 9% in these groups of four. The data is also presented in Figure 1. The second and fourth ranking group members seemed to benefit most dramatically in mediated initiations, even though the impact on the combined rates is only apparent for the high ranking member.

Automatic mediation appears to be a powerful method of balancing participation in group problem-solving. Participants found the mediation technique fair and easy to use. Some of their reactions to the automatic mediator (parliamentarian) are given in Table 4. A vast majority felt the mediator was fair to them and gave them an equal chance to speak. Of the two persons who disagreed that the mediator was fair to them, one indicated that it did give him/her an equal chance to speak. The other indicated that the mediator did not give him/her an equal chance and that he/she had spoken more in this experiment than he/she usually does in a group of the same size. Most persons indicated they spoke no more in the experiment than in other groups of the same size. Only one person had trouble learning to use the mediator technique. Generally the mediation procedure becomes transparent very rapidly when the programs function correctly. Participant attention focused upon the problem-solving task. When participants rated their groups from very cold (0) to very warm (5), the modal rating was quite warm (4), with the mean rating slightly lower (3.75). These ratings reflect not only the effect of the mediation procedure, but also the effect of the task and experimental environment. Thus they are to be interpreted with caution, especially considering the limited number of responses analyzed.

In this paper, the effect of an automatic resolution rule was described. Selection rules which do not wait for requests, but which select the new speaker upon termination of a prior comment can also balance participation. Simple evaluative responses can be transmitted through the anonymous response channel to the mediation mechanism and used to trigger outputs to the speaker. Both the additional mode of participation and the evaluation can have powerful effects. The independence of these responses permits the identification of biases which are not influenced by group pressures to conform. Feedback rules which reward accuracy and compensate for prior discrimination are under investigation for use in the classroom. Finally, evaluative feedback can directly influence the selection of speakers by mediation techniques which assign different priorities to speakers according to their prior performance and the specific juncture in dialog. Stodolsky (1978) has presented a theory of criticism based upon automatic mediation which develops this approach. Anonymous response systems with automatic rules offer significant theoretical and practical advantages in the investigation and facilitation of group problem-solving.

Table 1

First Order Speaker to Speaker Transitions

		To				
		0 Mediator	1 Kathryn	2 Daniel	3 Cliff	4 Tara-Nata
From	0 Mediator	12	55	13	51	90
	1 Kathryn	57	0	10	13	13
	2 Daniel	19	16	0	4	8
	3 Cliff	47	9	10	0	15
	4 Tara-Nata	79	17	14	15	0

Table 2

Fit of Horvath (1965) Model to Stodolsky (1976) Conferences
FIFO or Unresolved (Interspersed wai ing period)
(All Data with P=.39)

Group	E7		E8		E9		E10		Total:	All Groups:
	Act	Pre	Act	Pre	Act	Pre	Act	Pre	Actual	Predicted
1	74	70	64	71	62	77	47	48	247	263
2	50	43	44	43	53	47	31	29	178	162
3	26	26	29	26	33	28	18	18	106	99
4	5	16	20	16	21	17	10	11	56	61
	155	x^2 = 25.4	157	x^2 = .1	169	x^2 = 5.83	106	x^2 = .25	587	x^2 = 5.46

Subjects ranked in order of participation

Key: Act - Actual
Pre - Predicted

Table 3

Fit of Horvath (1965) Model to Stodolsky (1976) Conferences
Equal Time Resolution (Consecutive turns and combined)
(All Data with P=.3)

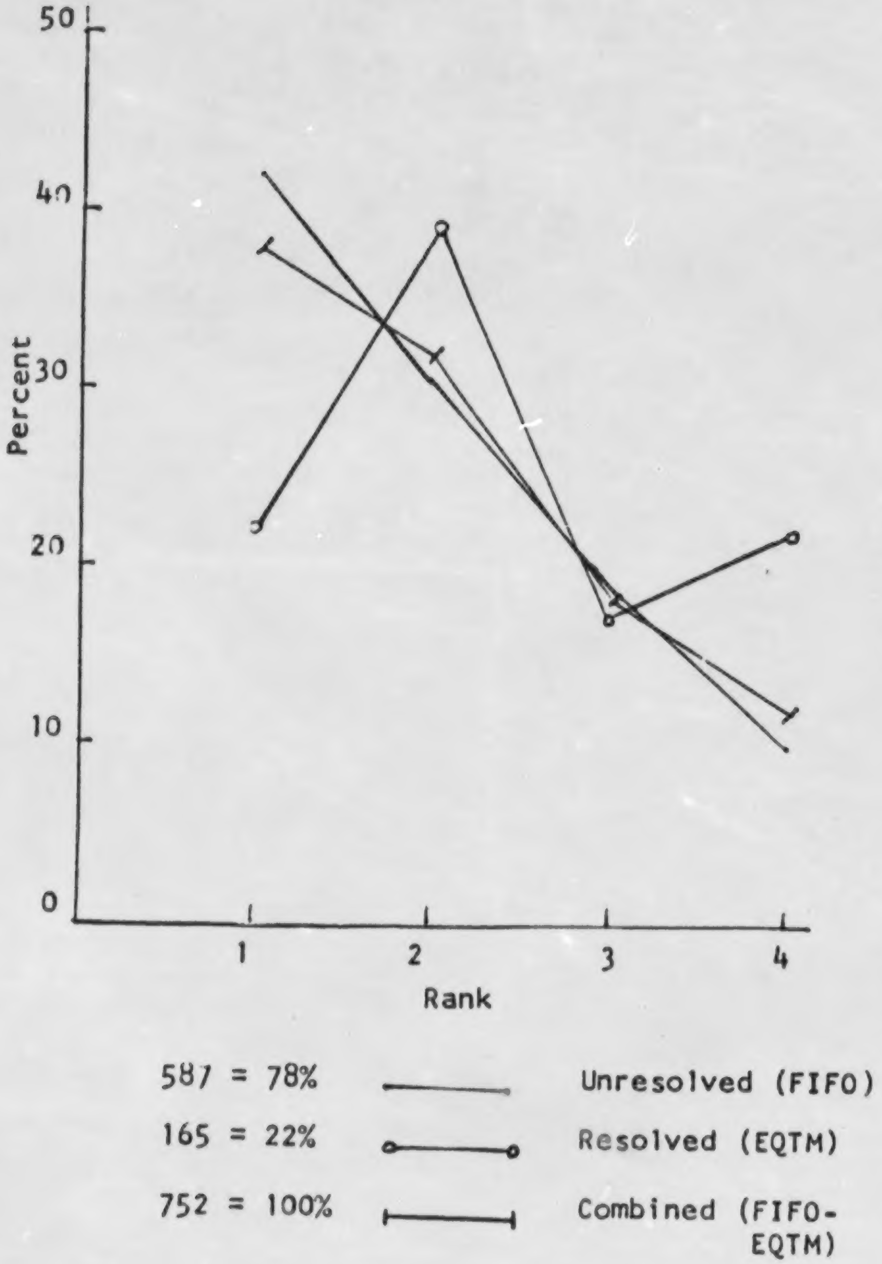
Group	E7		E8		E9		E10		Total:	All Groups:	
	Act	Pre	Act	Pre	Act	Pre	Act	Pre	Actual	Predicted	
1	4		17		9		6		36		
2	0		30		28		7		65		
3	2		11		7		8		28		
4	1		8		27		0		36		
										P=.3=.39	
1	78	64	81	88	71	95	53	49	283	297	338
2	50	45	74	62	81	66	38	35	243	208	206
3	28	31	40	43	40	46	24	24	134	145	126
4	6	22	28	30	48	32	10	17	92	102	77
	162	x^2=46	223	x^2= 2.92	240	x^2= 15.12	125	x^2= 5.44	752	x^2=7.72=9.25	

Table 4

Participant Reaction to the Automatic Mediator

Question	Yes %	Yes Number	No %	No Number
Was the parliamentarian fair to you?	87	14	13	2
Did the parliamentarian give you an equal chance to speak?	94	15	6	1
Did you speak more in this experiment than you usually do in a group of the same size?	13	2	87	14
Did you have trouble learning how to use the parliamentarian?	9	2	81	10

Figure 1


50
40
30
20
10
0
Percent
1
2
3
4
Rank
587 = 78%
Unresolved (FIFO)
165 = 22%
Resolved (EQTM)
752 = 100%
Combined (FIFO-EQTM)

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THE INSTRUCTIONAL EFFECTS OF CHARTING STUDENT PERFORMANCE DURING COMPUTER MANAGED INSTRUCTION

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Introduction

To be able to improve the rate of student progress through a course of instruction is not of present concern to the academic world with its fixed duration semesters, but is even now of primary concern to business, industrial, and military organizations. The concern felt by commercial and military interests is based essentially on the fact that for these organizations, students are salary-drawing employees. And longer instructional time means higher salary costs before the employee can become a productive member of the work force. Consequently, there is a continuing search for methods that will improve the student's instructional progress rate.

One technique for improving or maintaining progress has involved the use of progress charts for students in courses taught under Keller's (1968) Personalized System of Instruction. Semb, Conyers, Spencer, and Sosa (1975) combined various point award procedures with individualized use of a progress chart that allowed the student to view on a day-to-day basis his status with respect to a suggested rate of course completion (See Figure 1). In various conditions, points were either awarded or withdrawn contingent on whether the student's plotted progress was above or below the suggested rate-of-completion line. A uniform finding of this and other studies is that imposition of various pacing contingencies, although violating the theoretical sanctity of the feature of self-pacing, did not have an adverse impact on achievement, but permitted sizeable effects on the rate of progress through the course. It should be noted that this type of progress chart requires the ability to predict a progress rate for the individual student. Obviously, the accuracy of these predictions would greatly effect, both positively and negatively, actual progress rates, given the very real contingencies facing the students in the learning center.

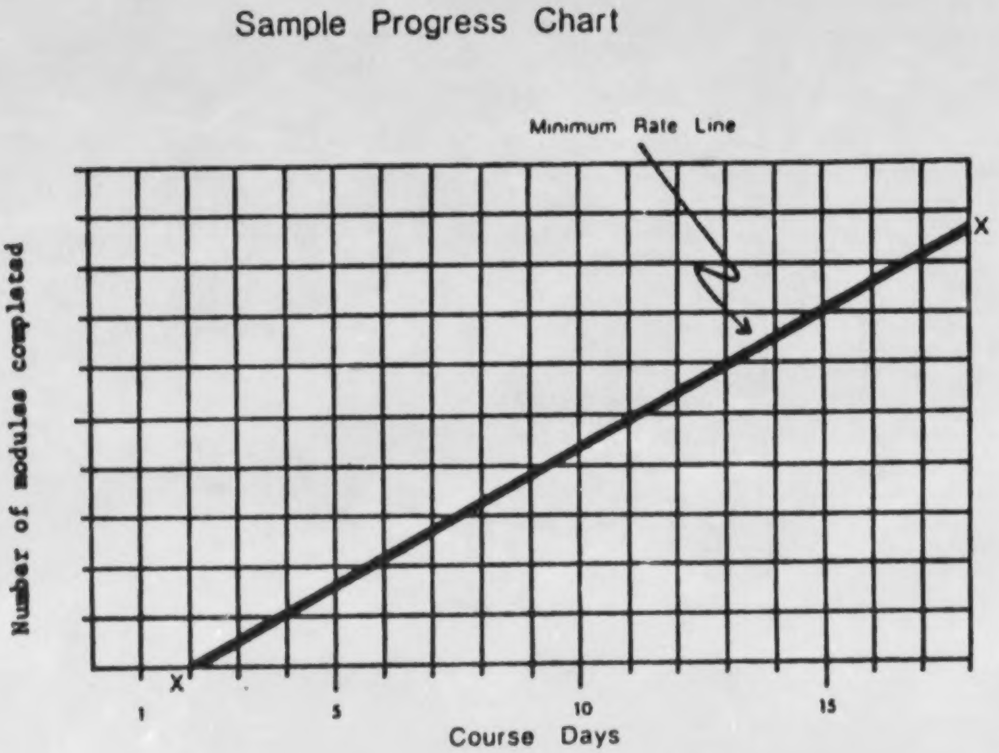

Figure 1. Sample progress chart showing the pre-determined rate line. (Adapted from Semb, et al., 1975)

The purpose of this investigation was to study the effect of introducing individual progress charts on instructional module completion times in a course taught under the Navy CMI system. Navy CMI uses off-line instructional materials, and off-line, mastery testing procedures. Answer sheets are submitted to an optical scanner and within about 20-30 seconds the student receives from a printer a response sheet which gives knowledge of results and a prescriptive study/test assignment or advances the student to the next module of instruction. Deficiencies on objectives can be eliminated by additional study and testing. A Honeywell computer Model 60/40, located in Memphis, TN, provides the scoring, record keeping, and prescriptive decision-making functions for the current nine schools situated in Tennessee, Florida, Illinois, and California. The Navy system has a comparatively sophisticated ability to predict student completion times for modules, based on aptitude test scores, age, and number of years of schooling completed. The predicted completion time (PCT) plays a major role in student management since instructors regularly monitor each student's progress against his predicted progress and can take severe action if too great a discrepancy appears. The student regularly spends six hours per day in the CMI learning center.

The primary objective of this research, then, was to determine whether provision of a chart-picture of the student's progress through a CMI course would reduce any negative discrepancy between actual and predicted completion times and result in a net savings of training time when compared to training time for students using CMI without benefit of the progress charts.

Approach

The study was conducted in the CMI learning centers at a Navy school teaching basic electronics. Students were randomly assigned to one of six conditions. These conditions were: existing school CMI instructional procedures without charts (Control), students manually draw their own progress charts (Self-chart), students automatically receive a chart at the end of each module of instruction (Constant), students receive a chart at the end of the module only when they ask for it (Demand), students are yoked to Demand students on the basis of their predicted completion times and receive charts when the yoked Demand student asked for it (Yoked), and the final condition was the Demand condition with available incentives and contingencies printed on charts (Demand and Incentives). Experimental conditions necessitated beginning students in the Yoked and Demand with Incentives conditions toward the end of the data collection period and consequently it was not possible to get the desired number of completed students through the course for these conditions. A sufficient number of students did complete the course to allow for an overall conditions data analysis. After students completed all modules of instruction they took a comprehensive examination covering the entire course. Students in all of the experimental conditions were assigned to one learning center, while the Control group students were assigned to a separate learning center.

To automatically distribute the progress charts, an IBM Model 5110 processor, along with an IBM dual-disk drive and printer, were programmed and placed in the learning center. Researchers operated the IBM 5110 and assisted in managing the chart distribution. It should be noted that the researchers did nothing that a regular Navy instructor couldn't do with minimal instruction. Navy instructors provided the normal tutorial and administrative assistance to the students.

Results

The dependent variable of paramount concern was the actual training time, in hours, to complete the course. Of secondary concern was the comprehsensive examination score. The research question to be answered focused on whether one of the chart conditions would result in significantly less training time than time for the Control group, but still have equivalent achievement. Since the Navy CMI system uses a criterion-referenced mastery testing procedure, completion of the course presumes at least a prescribed minimum competency. Table 1 presents the mean predicted and actual training time and comprehensive exam score for each group.

Table 1

Predicted and Actual Training Times and
Comprehensive Exam Scores for Each Experimental Group

Group (N)	MEAN TRAINING TIME (HOURS) Predicted	MEAN TRAINING TIME (HOURS) Actual	Comprehensive Exam Mean Scores
Control (38)	101.2	102.7	81.0
Self-chart (21)	106.2	105.7	79.7
Constant (16)	102.6	98.5	79.8
Demand (21)	104.1	94.7	81.7
Yoked (13)	98.1	96.86	77.8
Demand + Incentive (11)	105.3	87.3	82.5

Since differential individual abilities across groups could bias the results, a Mixed Analysis of Variance (Lindquist) was performed. This analysis accounts for any differential group bias due to ability. The analysis revealed a significant Group X (Actual-Predicted) interaction ($p < .05$). Post hoc Scheffe tests revealed significant mean differences between the Control group ($\overline{X}$ = 102.7) and the Demand ($\overline{X}$ = 94.7) and Demand with Incentive ($\overline{X}$ = 87.3) groups on actual training times. Since a school day consists of 6 hours of learning center instruction, the data show a savings of 1.3 days and 2.5 days for the Demand and Demand with Incentive conditions, respectively. Analysis of the comprehensive exam scores revealed no significant difference across groups. Since the comprehensive exam does have a required minimum score of 70 for passing, and remediation is provided to enable students to pass at the 70 level, these achievement scores represent a truncated range of scores, with scores less than 70 eliminated.

Conclusions

The use of instructional progress charts to improve student progress through an individualized CMI course are effective, particularly when the charts are provided automatically upon the students' demand, and when the chart illustrates not only student progress but also the availability of incentives. For the Navy, the list of incentives included only those currently available at the school. They are liberty (time off), a letter of appreciation, and a letter of commendation from the school Commanding Officer. The data show mean time savings, as compared to Control group actual times, of 8 to 15 hours, or 1 + to 2 + training days. If the results of only a one-day savings could be repeated in the entire electronics school complex on an operational basis, it would result in a possible training cost savings of over one million dollars annually. If the chart procedures were implemented into the entire CMI schools complex with similar savings, an even larger and continuing cost savings would occur.

The next research step is to demonstrate that the chart procedures are operationally effective across several schools, using Navy instructors instead of researchers, and using the CMI system's computer instead of the IBM 5110 processor. It would be appropriate at this time to improve the incentive distribution component of the charting system, since even greater time savings could result. However, it is critical that both achievement and morale be monitored and maintained as the effectiveness of the positive and negative contingencies is increased. It would be a grave error to develop a system so focused on time savings that necessary student achievement is sacrificed. Continued research effort to improve the predictions of student performance, both time and achievement, will serve to improve the utility of the progress charting techniques. All of these considerations will aid in making CMI a more cost-effective form of instruction.

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Linear Programmed Instruction Versus Computer-Assisted Instruction: A Comparison and Evaluation Of Achievement In Comma Usage Among Selected Post-Secondary Business Communication Students

Introduction

The ability to communicate without misunderstandings is a necessity for success in any occupation in today's complex business and industrial society.

To determine what communication skills are necessary for successful employees a recent survey (Dillie: 1976: 5-8) reported that in writing, "getting your point across" was the most important skill followed by spelling, appearance, and punctuation. The area of punctuation was ranked as "necessary" by 78.9 percent of the respondents. (Punctuation, of course, is also directly related to the top-ranked skill, "getting your point across.")

Yet, even with over 75 percent of present employees stating that punctuation skills are necessary, previous doctoral research from 1930 to 1970 reported that in as basic and necessary a skill as punctuation, "students have not mastered basic punctuation principles," and "punctuation may account for as high as 75 percent of all grammatical errors found in student transcripts."

Studies have been undertaken in an attempt to measure the punctuation ability of students. These studies have shown that most students are weak in punctuation skills, but little research has been completed to determine the best method for teaching punctuation. In fact, after extensive review, the writer was unable to find a reported study in punctuation usage that compared Programmed Instruction with Computer Assisted Instruction.

To date, the main drawback to comparing PI and CAI has been the lack of equality of these two procedures. Equality, in this sense, means that if one compares a good CAI instruction system with a poorly done PI instruction system, the computer system will be shown to be superior for the main reason that the programs were not comparable in quality of preparation.

To assure equality in the instructional programs being compared, an existing CAI punctuation package, which is presently used at the University of Akron, was converted to a "linear" PI package. This conversion was done using the exact program, including all directions, pretests, rules, illustrations, and posttests, to provide the greatest possible equivalence. In addition, instructions were added for both CAI and PI allowing students who made a maximum of two errors in each section to either move to the next section or to receive additional practice.

This study provided an opportunity to compare equivalent programs, PI and CAI, and adds to the limited amount of research, with regard to punctuation usage, utilizing two-year college students. To date, research in the punctuation area has been largely confined to elementary, junior high, and high school students.

Purpose

In this study, answers were sought to two principal research questions: (1) When two-year college Business Communication students are given instruction in the uses of the comma, are there significant differences in achievement by recipients of CAI, of PI (Programmed Instruction text materials), and of traditional classroom instruction? (2) Is there a significant difference in completion time between the recipients of CAI and those receiving PI?

Method

During the Spring of 1978, 172 two-year college students were randomly assigned to three treatment groups, each employing a different method for the teaching of the uses of the comma. One group received computer-assisted instruction, another received identical programmed instruction in written form, and the third received regular classroom instruction.

Teachers and classes were assigned to specific treatment, testing, and control groups using a table of random numbers. Also, students in six of the eight classes under investigation were randomly assigned to either of two treatment groups--PI or CAI. Students in two assigned classes served as control groups, and received no treatment.

The students in the experimental classes completed instruction and drill in comma rules. During the two-week treatment period, students worked by themselves on the punctuation packets. A record of time that each student spent completing the punctuation packets was kept.

To further determine the effectiveness of the CAI, PI programs, a pretest was given to five of the eight classes. The three classes not receiving a pretest were used as a check of the effect of pretest sensitivity. To assess the effectiveness of the treatment, all subjects received a posttest and a one-month retention test.

The three different test instruments used in this study consisted of fifty randomly chosen punctuation questions taken from a pool of 125 questions. Questions were chosen to survey the thirteen comma rules being presented. Questions covering each of the thirteen comma rules were included. All questions in the testing instrument required the student to supply missing punctuation by shading in one or more locations of a ten-answer standard survey sheet. (Many questions required multiple answers.)

The combined KR-20 reliability for the pretest was .923. The combined KR-20 reliability for the posttest was .920.

The time taken for completing the pretests, posttests, and retention tests ranged from 20 to 35 minutes.

In addition to the test and survey information, the researcher added, without student knowledge, each student's cumulative Grade Point Average, American College Testing score in English, and the time in minutes each student in the experimental groups needed to complete the individual instruction, PI or CAI. This information was added in order to determine if GPA, ACT in English, or completion time in minutes had any extraneous effect on achievement scores.

A research design similar to one suggested by Campbell and Stanley--Separate-Sample Pretest, Posttest, Control Group Design, 13a, was the experimental design used in this investigation.

The major research questions mentioned previously generated ten specific hypotheses, all of which were tested as null hypotheses. Because both categorical variables (sex, control, or treatment, completion or non-completion of Business English) and continuous variables (GPA, achievement scores, ACT, English scores, time in minutes, and age) were included, the multiple regression statistical technique was chosen as superior over the traditional ANOVA technique. An F-ratio was obtained for each hypothesis, and the decision to reject or fail to reject each hypothesis was based on an .05 level of statistical significance.

Results

Although CAI students achieved higher gain scores than (on both posttest and retention tests) students in the other groups, statistically significant differences were not found. An interaction effect due to prior training is suspected. Completion time, however, was significantly less for CAI students than for students in the other groups. In fact, a comparison of time differences--the amount of time it took each student to complete a review of punctuation--revealed that there was a significant (.00001) time difference (35.990 minutes, mean difference) in favor of the CAI treatment. Thus, when compared with PI, CAI students finished the punctuation review 40 percent faster.

Conclusions

Data analysis showed that the CAI groups, even though they completed the package significantly faster, had higher gain scores (pretest over posttest and retention scores) than either the next closest groups, PI and regular classroom instruction. This higher gain score achievement by the CAI group, although not statistically significant because of the interaction of prior training, coupled with the significant time differences, seems to indicate that CAI instruction should be the chosen mode of instruction in comma review.

In addition, CAI student ratings for the Likert type questions were consistently higher over PI in both the effectiveness and attitude sections.

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Computers and Educational Institutions

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Although the role of computers in education has been much discussed, there seems to be relatively little literature or thought concerning how the coming use of computers in the learning process will affect our educational institutions. The present paper discusses some possibilities with the hope of creating further dialog in this important area. If institutions are completely unprepared for what may happen, the consequences may, in many cases, be grave.

I begin by giving a quick view of the future of computers in education as I conceive it. Then I discuss the impact of this future on traditional institutions. Finally, I end with a section concerning new types of institutions which will be developed partially based on widespread use of computer technology. In all this discussion I will use computer as a generic term, covering also such systems as intelligent videodisc systems that combine the computer as a learning device along with other important newly developing technologies.

Directions for Computers in Learning

In the past fifteen years we have seen a large number of experimental efforts in developing computer-based learning material. Much of this effort has gone into understanding the medium. Relatively little that has been produced now will prove to be of long-range value. But we are beginning to understand how the computer can be used effectively to individualize and personalize education, to provide a more humane experience for students than usually seen in such school environments as the large lecture. Furthermore, we are seeing that the computer can bring interactive learning possibilities to each student, again in contrast to lecture and text learning for many students.

We now have a series of compelling examples that show the computer can be effective in a wide variety of different styles and procedures, and other even more interesting examples are now under development.

We also are beginning to have a much better understanding of the authoring process. Early authoring almost always worked from a cottage industry base, with one person or a small group responsible for the pedagogy, the artwork, the programming, and the distribution. A number of projects now, however, have taken as their task the analysis of the authoring process, and we can already see that something more like the mechanisms involved in book production will be involved in this area too, with many different specialists. I have written extensively about this authoring process elsewhere, and would be happy to furnish additional material to those interested.

In spite of the advances mentioned, relatively little computer-based learning material is in standard use in any level of education in the United States. There are exceptions in particular schools, but even in those schools the computer functions as the delivery system for only a very small fraction of the total student time spent in learning activities.

The early experimental work in using the computer as a learning device has proceeded on timesharing systems of various sizes. Often these systems had built-in limitations, based on inadequate early experience. But the thrust of computer hardware in the last few years has been moving very strongly in the stand-alone direction. LSI technology puts great emphasis on volume. It is much cheaper to make millions of CPU's of a given power than to make a dozen CPU's with that same power. Furthermore, removing communication barriers entirely allows much more effective use of important graphic capabilities. I believe that time-sharing as a mode for delivery of computer-based education will soon be an extinct phenomenon. Rather, the personal computer will be dominant.

Perhaps the driving force that we need to pay most attention to is that of decreasing cost of computing. In no other area of human endeavor can one find such dramatic decreases; almost every other cost associated with education is continuing to rise.

These factors strongly suggest that computers will become much more widely used in the educational process than they are at the present time. Indeed, in many areas and in many types of institutions the computer will soon be one of the dominant delivery systems for learning. An important key factor will be the commercial production and distribution of such materials in the personal computer environment.

Traditional Institutions

In addition to the impact of increasing effectiveness in using the computer and rapidly decreasing computer costs, we must take into account other factors influencing our current traditional institutions over the wide spectrum from elementary childhood education to adult education.

Perhaps the most obvious factor is the increasing public unhappiness with education as reflected in ballots in many different areas of the country and as reflected by unfriendly state legislatures. Measures such as Proposition 13 in California affect all types of education, even though only public school systems and community colleges rely directly on the property tax base. Criticism of education is widespread in many newspapers and journals. Often this unhappiness is reflected in severe fund cuts, and we can expect, according to most of students of this area, this situation to deteriorate further in the period of the 1980's.

Another set of problems arises from demographic factors. These factors have already influenced the elementary schools, and are now moving up the educational ladder. It is estimated, based on the people actually alive today, that there will be 19% fewer eighteen year olds in 1990 than there are in 1980. Implications for universities are clear.

Given this depressing situation it is clear that the survival of many institutions will depend on whatever aids the institutions can get from new technology.

Computers for learning will be coming into our institutions just at the time when the institutions will be most desperate for help. It will not be an unmixed blessing, because they will be another contributor to the turmoil. But at least computers have possibilities of making positive as opposed to negative contributions.

The first change to be noted in the universities is that computers will allow more effective learning situations. The computer will be very competitive with many of the modes of learning, such as the lecture situation, now common in universities. Even the textbook may be threatened as the increasing cost of books is now putting them in a category where electronic delivery of the same material, through both school and home machines, will soon be cheaper than paper delivery. Such a change will not occur easily.

A key development in this new era will be greater flexibility. This flexibility will show itself in many ways. First, students will be given greater time control as to how they will move through courses, so the slower students, needing more background work in a given area, will still be able to learn the same subject matter as the student with an excellent background. Going along with student control of pacing will be computer-based record keeping systems that will move much of the menial labor that teachers now engage in.

Fixed time span for education will also be a casualty. That is, we can see an environment where open entry, open leaving courses will be the critical one, and in fact even the distinction between courses themselves may vanish. There are already some experiments in this direction, and we can expect more.

Going along with the institutional changes will be changes in faculty role. First, relatively more of the faculty time will be spent on the development of the learning materials and relatively little time on delivery. Faculty will work less with large group environments and will spend more time helping individual students, particularly students who are weak in background or students who are zooming through the material at more than the normal rate and so need additional material to work on.

Nontraditional Learning Modes

While the computer will have considerable impact on present formal teaching establishments, it will also encourage the development of new modes of learning. New learning centers will rise which will to some extent compete with the traditional institutions.

We are beginning to see at the present time the development of the computer as a home appliance, a device costing the same as a refrigerator or color television set and and becoming more and more common in the home. Several vendors already are actively marketing in this area, and a number of others can be expected in the not-too-distant future.

Unlike the hobbyist market, the home buyers of computer equipment will be buying it primarily for what it can accomplish. Hence, we can expect a market to develop for materials to use on these systems. Education will be an important component of that market. Much of this will be stimulated by the vendors themselves, realizing that it will only be through the existence of effective and interesting material that people will be encouraged to buy the home computers. This material will have to go far beyond game-like material, because the computer games will cost much less than the full-scale computer.

Thus, we can see a rise in importance of home education based on computer technology. Whether this will impact the traditional schools, with more of the activities of the traditional schools taking place in the home and with credit for the home part of the courses, remains to be seen. But it will certainly lead to some new kinds of institutional structures to be discussed later.

Another promising new environment for computer technology is the public library. Libraries at the present time are primarily book-oriented. But most of them are attempting to move toward a multimedia stance. I have in mind particularly the public libraries that have put in such things as records, videotapes, slides, and other related material. The personal stand-alone computer, with its emphasis on individualized instruction and its ability to function quietly, will be a natural ingredient for public libraries. My discussions with public library officials also show that they are more than willing to consider such possibilities.

In the last two paragraphs we have discussed primarily delivery sites, places where learning might take place other than in the traditional institution. But many other factors must be considered other than just the sites. Is this learning to be informal study, or it is to lead to some sort of credit or eventual degree? It is my own feeling that there will be less emphasis on the degree aspects of learning, and therefore less on the credit aspects in some areas. But on the other hand, adult education, renewal of skills and demonstration that skills are still available in many professional areas, will become more and more common.

Nevertheless, there will be certainly some interest in obtaining of degrees and associated credit, even in nontraditional environments. The most likely possibility here will be the development of organizations similar to the Open University in England, or, to some extent, to the University of Mid-America in this country. These existing organizations were formed at a time before the computer was ready to play a major role in education. Hence, their developmental procedures have not stressed the computer to any great extent. It may be difficult, given the patterns that have already been established within these institutions, to move in such computer-oriented directions.

But we may well find new learning-at-a-distance institutions will be able to capitalize on computers. Indeed, these new institutions may be based primarily on the efficacy of the computer as an educational delivery system. These new institutions may receive sizable amounts of government funding. The notion of learning at a distance, learning that does not necessarily take place in formal environments, has a great deal of appeal to many people who cannot for one reason or another get close to a formal environment, or who are repelled by the formal environment.

Some of these new types of institutions will be primarily production institutions, concerned with the production of computer-aided learning materials and other associated learning materials. Others will play a role of distribtuion of these materials, while a third will be concerned with course and credit arrangements. Sometimes these three aspects will be combined, but we are already seeing institutions that specialize in one or the other. Thus, the University of Mid-America has been primarily concerned with the first two aspects, while some of the larger extension services in the United States have had some concern with the first, but have focused primarily on the second. The Open University in England clearly views all three as within its bailiwick.

In addition to the learning-at-a-distance institutions, employing the home, public libraries, or other community environments, we can expect other types of nontraditional institutions to develop, ones that are more closely related to the present institutions, but which have different emphases. Many of these will be company-related. We can see beginnings of this movement in such institutions as Holiday Inn University or in some of the other extensive training centers in large corporations. While traditional academics tend to dismiss these institutions with scorn, they often are teaching a full range of activities with learning standards that are just as high or higher than those of our traditional two- and four-year institutions.

Final Comments

It is likely that the fourth revolution, the extensive use of instructional technology to assist learning, will be accompanied by sizable institutional changes. The comments in this short paper are not exhaustive, but only intended to suggest some of the possibilities in the hopes that a more active discussion of these issues will be engendered.

Relationship of College Students' Study Skills and Locus of Control Orientation with Achievement in a Self Paced - Computer Managed Course of Instruction

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Learner control of CBE applications has been an enticing topic of research. Reviews by Steinberg (1977) and Taylor (1976) indicate that effects upon achievement are equivocal when learner control has been compared with program or instructor control. The mixed results suggest the possibility of an interaction between certain aspects of instruction and characteristics of the learner, when the learner is permitted to control the program.

Current theory and data suggest that an extremely important variable related to academic success is the student's perceived locus of control. Some individuals have a general expectation of being able to influence the environment and control sources of reinforcement, success and failure (high internal orientation). Other individuals have a general expectation of being controlled and having little or no influence on significant sources of reinforcement, and that success and failure are matters of chance or the effect of powerful others (high external orientation). These orientations have been shown to have a very significant relationship to academic success (Coleman, et al, 1966; deCharms, 1976).

Behaviors exhibited by those having high internal or high external orientations (Crandall, et al, 1965; Seeman, 1963; Seeman & Evans, 1962) appear to be closely related to successful use of opportunities that permit one to control the conditions of learning. It was hypothesized in this study that high internals would be more likely to explore and profit from learner control opportunities than would high externals. The I-E Scale developed by Rotter (1966) was considered to be an appropriate measure of this characteristic for college students.

A more direct measure of achievement-striving behavior is the SSHA (Survey of Study Habits and Attitudes, Brown & Holtzman, 1967). This assesses the tendency of students to be prompt, to employ effective work methods, and to possess positive attitudes towards teachers and schooling. SSHA has been shown to be related to grade point average of college students (Brown & Holtzman, 1967; Desiderato & Koskinen, 1969) and to exam scores (Wen & Liu, 1976). It has also been shown that the SSHA and the I-E are related (Ramanaian et al., 1975).

It was hypothesized for this study that effective study habits would facilitate one's efforts to learn, and that this variable should interact with I-E when students are given an opportunity to excercise control. It was also hypothesized that these variables would be particularly salient in a self-paced CMI application where the instructor controlled the operating parameters of the computer program during the first half of the course and the students controlled the operating parameters during the second half of the course. Under such conditions, students who differ on these variables should exhibit even greater differences on achievement as the course progresses.

METHOD

Subjects

One hundred thirty three students enrolled in a junior level college course on educational measurement during the spring quarter of 1978 constituted the original sample. All students were taught by the same instructional team. Measures listed below were secured for one hundred two of these students. The remaining students either withdrew from the course very early in the quarter or were absent on the days the I-E and SSHA were administered.

Instruments

Rotter's I-E Scale and the Brown-Holtzman SSHA were administered during regular class meetings. The I-E was administered during second week of the quarter; the SSHA was administered during the fifth week of the quarter. All students were given individual feedback about these measures at the end of the quarter. A brief description of each is presented below:

1. I-E Scale. This scale contains 29 forced-choice items, including six filler items, and was keyed so that a high score indicated a high internal orientation.

2. SSHA. This inventory contains 100 items grouped into the following subscales:

- a. Delay Avoidance (DA). Lack of procrastination.
- b. Work Methods (WM). Effective study procedures.
- c. Study Habits (SH). DA plus WM
- d. Teacher Approval (TA). Attitude towards teachers and their behavior.
- e. Education Acceptance (EA). Attitude towards educational practices.
- f. Study Attitudes (SA). TA plus EA
- g. Study Orientation (SO). SH plus SA (overall measure)

3. Comprehensive Exams. Achievement in each of four units of work was measured by thirty item selection type exams. Two or three alternate forms were available for each unit. Exams used were a regular part of the course. Item analyses indicate acceptable quality. Measures of reliability have ranged from .70 to more than .90. Method of estimating reliability, number of students involved, and term when analysis was conducted, varied from one set of unit exams to another.

4. GPA. Overall grade point average at end of spring quarter was obtained from the registrar's records. This measure has been shown to be correlated with academic achievement in the measurement course (Blumenfeld, et al. 1975) and with research on learner control in CAI (Taylor, 1976).

Procedures

Student behavior and achievement was examined under conditions imposed by self-paced computer managed instruction applied to an undergraduate educational measurement course. A brief description of the course and the computer program is given below. More detailed accounts can be found in Blumenfeld, et al. (1975) and Blumenfeld, et al. (1977).

1. Measurement Course. Emphasis is placed upon evaluating the effectiveness of instruction and upon developing coordinated sets of instructional objectives, instructional procedures, and measurement procedures. The course is divided into four units and one teaching project. The teaching project is not self-paced and student behavior related to this aspect of the course was not included in the analysis. The units are divided into modules - three modules per unit. Students are given ten to fifteen behaviorally stated

objectives for each module. They are required to take module study quizzes via computer terminals on each unit they study prior to taking comprehensive exams. Study quizzes are taken outside of regular class time and are scheduled by the student at his or her convenience. Comprehensive exams are given during regular class time during six predetermined sessions distributed throughout the term. Criterion for passing a unit exam is 80%. A student may take a second exam on each unit if he fails to pass the first time. A few target points awarded at the beginning of the term, to encourage students to get started, permit a few students to pass unit I with only 70% correct. Course grade is determined by the number of units the student passes. If the student passes four units, a grade of A is recorded; three units, a grade of B is recorded, etc. Minus grades are given if students achieve 70% but not 80%. The student can decide to work on all four units or to stop after one. Upon request, incompletes are awarded to permit a student to complete one additional unit. Only work completed during the spring term was included in the analysis.

The topics included in modules one thru six are repeated in modules seven thru twelve. Objectives in the first six modules include critical concepts and less difficult tasks. Objectives in the last six modules include more advanced ideas and more difficult tasks.

2. Computer Program. The program contains twelve quizzes with each quiz containing twelve items. A pool of five selection type items is included for each objective. When a student signs on, the program randomly orders the objectives and randomly selects one item for each objective. Emphasis is provided by including two five item pools for some objectives and repeating these objectives. After a correct answer, the student is so informed. Appropriate page references for three books follow both correct and incorrect answers. If an incorrect answer is given, the student is informed as to why the answer is not correct. Correct answers are not given, but the student is provided with some direction for reconsidering the problem. At the end of the quiz the student can see a list of objectives related to the items they answered incorrectly.

Criterion for passing is ten correct answers. If the student meets the criterion the program advances the student to the next module. If the student fails to meet the criterion a second or third study quiz on that module is required. A delay of ten minutes per error is imposed before the student is permitted to take another quiz. Students failing a module quiz for the third time are advanced to the next module. A student who fails three quizzes on two consecutive modules is not permitted to continue until he obtains a "password" from the instructor. After the student has completed module six, control of the computer program is given to the student. The student decides which module to go to, how many times to take a quiz on that module, and in what order to repeat modules if he so chooses. The student can avoid any delay imposed earlier because of errors.

RESULTS

Intercorrelations of Measures

Table 1 lists the intercorrelations of the SSHA scales, I-E and GPA. It is interesting to note that all correlations are significant except those involving I-E.

TABLE 1

Intercorrelation of the SSHA Scales,
I-E and GPA

	DA	WM	SH	TA	EA	SO	IE	GPA
DA		.59	.89	.50	.67	.82	..07	.33
WM			.89	.65	.63	.84	-.08	.36
SH				.65	.73	.94	-.01	.39
TA					.77	.84	-.06	.23
EA						.89	-.12	.30
SO							-.06	.35
IE								.09

(r ≥ .195 significant at .05 level)
(r ≥ .254 significant at .01 level)

Table 2 indicates the relationship of these variables with unit exam scores. It can be observed that while GPA and I-E are significantly related to unit exam scores, SSHA scales are not.

TABLE 2

Correlations of SSHA Sales,
I-E and GPA with Unit Exam Scores

	DA	WM	SH	TA	EA	SO	IE	GPA
Unit I Exam	.03	.20	.13	.11	-.04	.09	.29	.46
Unit II Exam	.10	.15	.14	.05	.01	.09	.35	.31
Unit III Exam	.18	.12	.16	.11	.06	.13	.33	.37
Unit IV Exam	.26	.16	.23	.08	.11	.19	.19	.38

($r \geq .195$ significant at .05 level)
($r \geq .254$ significant at .01 level)

Regression Analysis

To test the original hypotheses that I-E orientation and study skills would be salient variables further analyses were conducted using DA and SH since the relationship of the other scales to unit exams was not significant. Full and restricted regression models were used to examine the predictiveness of GPA, SH, I-E, and (SH * I-E) when the criterion was unit exam score. Regression models were computed for each of the four unit exams. GPA was included in all models. Therefore, tests conducted determined whether or not SH, I-E and (SH * I-E) could account for a significant amount of criterion variance above and beyond that accounted for by GPA. The interaction (SH * I-E) was found not to be statistically significant, nor was SH. However, I-E was found to be significant at the .01 level for units I, II, and III and at the .05 level for unit IV. The multiple R^2 for the full and restricted models are given in Table 3.

TABLE 3

Regression Analysis Models Indicating Significance of I-E

Criterion	R^2 of Full Model (GPA, SH, IE)	R^2 of Restricted Model (GPA, SH)	F	df	p
Unit I Exam	.28	.21	8.577	1,98	<.01
Unit II Exam	.21	.10	13.502	1,98	<.001
Unit III Exam	.23	.13	11.744	1,98	<.001
Unit IV Exam	.18	.15	3.158	1,98	<.05

Comparison of full and restricted models indicates that I-E accounts for a significant amount of exam score variance beyond that accounted for by GPA.

Trend Analysis

One of the original hypotheses predicted that the difference in achievement between students who scored high and low on study skills would increase as the term progressed. Correlations between SSHA scales and unit exams indicated that DA was the most likely scale to generate a significant trend. Cumulative exam scores across the four units were recorded for both the top and bottom twenty five students on the delay avoidance scale. Traditional analysis of variance for trend was inappropriate because of extreme heterogeniety of variance. Therefore, log-log transformations were made for each student's cumulative exam score curve.

The slope of the regression line for each of these log-log transformations was computed. This was used as a measure of trend. The means of the slopes for the two groups were .86 and .65; the variances were .05 and .08. Students who scored high on DA had the higher mean slope. A test of these values indicated that the difference between the means of the slopes was significant at the .01 level. Obtained t was 2.776 with df = 48.

Use of CMI Program

No directional hypotheses with respect to student utilization of the CMI program were formulated. However, it is reasonable to assume that successful students will utilize learning resources differently than less successful students. The twenty five students who had the highest score on a combination of I-E and DA were identified along with the twenty five students who had the lowest score on this variable. The variable was obtained by multiplying each student's I-E score by his DA score. The mean number of quizzes per module and the mean number of minutes per module were computed for each of these groups. Only the first nine modules were considered because a very small percentage of students worked on Unit IV. This fact will be considered later. Nine out of nine times the high group's mean number of quizzes per module was greater than the mean of the low group. Eight out of nine times the mean of the high group's number of minutes per module was greater than the mean of the low group. On the average, members of the high group took more study quizzes, but spent less time per quiz than did members of the low group.

Discussion

It is important to note at the beginning of this discussion that an unusually small percentage of students worked on unit IV during the term the data was collected. For example, thirty six percent of the students listed on our first day roster for the previous quarter worked throughout the term and received a grade of A or A- for the course. During the quarter the data was collected only sixteen percent of the students listed on our first day roster worked throughout the term and received a grade of A or A-. A non-scientific explanation is that Akron students suffered thru a very difficult winter. When the sun finally appeared during the spring quarter, students stopped working on all non-required school tasks. We observed this sudden cessation of study and were given this answer when we raised questions about it. The authors are willing to assume that this resulted in a restriction in the range of the dependent variables and does not invalidate the obtained results. But given this unusual event, the data should be considered in a more tentative manner than would otherwise be indicated.

The reduced number of students working on units III and IV made a comparison of student behavior under instructor control of the CMI program with student behavior under student control impossible to conduct. However, the data does suggest that locus of control orientation and study skills should be given further study when CBE applications are of concern. Both GPA and I-E are significantly correlated with unit exam scores but uncorrelated with each other. The measurement course permitted students to take initiative from the very beginning with respect to when they would study, how much practice they would acquire, and how much of the course material they would attempt to master. Most of the students' previous courses, which entered into their overall GPA, would not have permitted this much control. Under our conditions students with high internal orientation had the opportunity to explore the many options and appeared to do so. Students with high external orientation appear to have remained overwhelmed by the many aspects of the course and the varied opportunities.

These conclusions are also supported by the data on number of quizzes per module and amount of time per module. As early as unit II, the mean number of quizzes per module taken by the high (DA * I-E) group was greater than 3.00. This could only have occurred if these students were either deliberately failing to pass a module quiz in order to avoid being advanced to the next module or returning to these modules after passing module six. The low (DA * I-E) group did not average more than three quizzes per module until unit III. By that time the high group was averaging more than five quizzes per module. When combined with the time factor, this suggests that the high students were not only practicing more but also distributing their practice across a greater number of examples. Such differential utilization of instructional options could affect the outcome of research on learner control vs. program control. It also suggests the need for differential monitoring of various types of students when student achievement is of primary concern.

The significance of the delay avoidance scale when examining cumulative performance has some logical validity when considering self-paced programs. The absence of a general relationship between SSHA scales and exam scores was unexpected. Previous research has demonstrated such relationships. The result could be attributed either to the inclusion of only students seeking teacher certification, or to the self-paced aspects of the course. Since these scales are correlated with GPA, and since most college classes are not self-paced, it may be that the characteristics tapped by these measures are those required for success in courses that are more traditional in structure. It may also be the case that the extreme degree of specificity with respect to objectives, the CMI program, the availability of individual help from graduate assistants, and the multiple opportunities to attain criterion on unit exams compensated for differences on these characteristics.

Optimal utilization of CBE facilities may ultimately require a matching of type of program, program control, and student characteristics (personality, learning style, study skills, etc.) While CPA indicates general academic ability and adaptability, it would not be available in all settings, e.g. elementary school and industry. It may not be predictive of achievement outside of an academic environment. I-E was predictive of performance beyond that which could be accounted for by GPA. Measures such as I-E and DA are easily secured both in school and in industry. And I-E scores indicate a general characteristic of the individual - not something that is solely associated with academic situations. Where optimal utilization is of concern, further consideration of the types of variables examined here is warranted.

Summary

A measure of internal vs. external locus of control orientation and measures of study skills and habits were administered to more than one hundred students enrolled in a junior level educational measurement course. Results indicate that the I-E orientation accounts for a significant amount of variation in student exam performance when controlling for differences in overall grade point average. Measures of study skills and habits were not generally related to course exam scores, although the delay avoidance scale predicted trends across units when cumulative exam scores were examined. Students who scored high on both DA and on internal orientation used the CMI program to acquire more and more varied practice than did students who scored low on these measures. The data suggests that student characteristics can influence the effectiveness of various CBE applications that permit student control.

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The Development of General Multivariate Software*

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I. Overview

1. Introduction - As one dimension of our Research Initiation and Support grant (RIAS - see Horn and McArdle, 1978) from the National Science Foundation we are training Ph.D. level psychologists to make effective use of modern computer techniques for the analysis of their inherently multivariate data. To be successful at this task we believe that this requires both general multivariate theory and general multivariate computer programs. This is not the usual way that most behavioral science training is accomplished, nor is it the state-of-the-art in Computer Software. Both educational and computer training in the advanced Social Sciences is still based on a rather amorphous set of cookbook methods and programs with which only a few scientists can become familiar. The RIAS goal in this respect is to link up the scientific theories with general calculation procedures. In this section we discuss ideas relevant to the state-of-the-art in education and computations as motivation for the possibility of a different perspective. This new route, while in danger of being a primrose path, is stated in some detail in the following sections. The goal of this paper is to describe the rationale for the effort we are taking in the development of a general multivariate software system.

2. Current Educational Practices - A fundamental function of any experimental science is the design and analysis of experiments. These two features go hand in hand because almost any researcher would not design data collection methods that they knew had no associated analytic method. This is not to say that this is not done or that methods are not inappropriately used, but more importantly, that available analytic methodology has a definite limiting effect on design ventures.

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Before leaping too far let us consider some anlytic tools and their current educational status. Table 1 presents a short overview of some methods for investigating the relationships between variables. We phrase this in terms of only two variable sets, with the familiar terms Independent and Dependent. By noting the assumed level of measurement, presented here as either Nominal (N) or Interval (I), and the number of varisbles (0, 1 to P) we can simply follow this chart in Cookbook fashion to determine the appropriate analytic method for a given design. We have assumed that the researcher wishes to do a simultaneous analysis when P variables are present. While this complicates the mathematics considerably it represents an appropriate analytic step, when used correctly, and is at the very heart of all multivariate analyses (Bock, 1975). Several important features of this cookbook are notable. The first is that analyses proceed to become more complex as we move down the page. The effect noted is that of increasing the number of variables with which we are dealing. The second is that mixtures of scaling, especially where the independents are interval and the dependents are nominal, leads to a confused situation with no true analytic base (denoted by a "?"). Things could become increasingly more complex if we wished to introduce mixtures of scaling within the P measures, however, matters seem confused enough already. The first basic point to be made here is that all analytic techniques can be seen as subsets of more general multivariate models. Generally, only items 11 to 20 are considered "multivariate" due to their nature of having a "more than one dependent variable" design. But any of these methods can be seen, and in some cases directly calculated, out of the general multivariate equations. We note that the most general models are those of the Log-Linear Models (Bock, 1975), Canonical, and Linear Structural Relations (LISREL - Joreskog and Sorbom, 1978). The standard way that these ideas are presented to the researcher is in the simple-to-complex, or from top-to-bottom fashion, quickly skipping the "?". The reason that is usually done is due to the difficulties in mathematico/statistico equations. The level of understanding about these methods is constrained by the level of formal math/stat training. Usually, this pure math/stat training is formally stopped unless one happens to be studying methodology as a content area or works with a consultant on a special problem. The

Table 1: The Statistical "Cookbook" Approach

IF YOU HAVE THESE TYPE OF VARIABLES USE THIS

	Independent		Dependent		
	Number	Scaling	Number	Scaling	Standard Statistical Procedure
1.	0	-	1	N	Frequency
2.	0	-	1	I	Plot
3.	1	N	1	N	χ^2 (chi-square)
4.	1	N	1	I	t-test/ANOVA
5.	1	I	1	N	Point Biserial (PB) Corr. (r)
6.	1	I	1	I	Product Moment (PM) r
7.	P	N	1	N	χ^2/Log-Linear
8.	P	N	1	I	Factorial ANOVA
9.	P	I	1	N	PB Regression ?
10.	P	I	1	I	PM Regression
11.	0	-	P	N	Histogram/χ^2/Multidim. Scaling
12.	0	-	P	I	Components/Factor Analysis
13.	1	N	P	N	Log-Linear Models
14.	1	N	P	I	T^2-test/MANOVA
15.	1	I	P	N	Many PB ?
16.	1	I	P	I	Many PM ?
17.	P	N	P	N	Log-Linear Models
18.	P	N	P	I	Factorial MANOVA
19.	P	I	P	N	Many PB Regressions ?
20.	P	I	P	I	Canonical/LISREL

Notes: $p>1$
N = Nominal and I = Interval
MANOVA includes Discriminant Function Analysis, ANCOVA, and MANOVA as special cases

great majority of behavioral scientists obtain only a small but detailed sample of the upper portion of the cookbook. We contend here that this has created a generation of "t-test thinkers" rather than those who grasp the more abstract principles inherent in "relations among variables". The work of Cohen (1968), who showed the formal equivalence between ANOVA and regression analyses, was a milestone in opening up the possible "ways of thinking about data". This in stark contrast with the usual status of methods where books such as Siegel's (1956) treatment with a nonparametric cookbook is still widely used or a guide such as Andrew's et al. (1975) is highly sought out. In general, however, multivariate analyses can be paradoxically considered as both opening up and closing out theoretical ideas. Whereas some methods to be discussed will allow a great unification of complex data they also will constrain the field of possible scientific inquiry into those that can be pragmatically resolved. When we witness someone doing separate t-tests/ANOVA on correlated variables it is quite easy to point out the virtues of the T^2/MANOVA tests. But when we witness a creative data analyst doing multiple-set canonical correlations we may believe we have hit the pinnacle of our knowledge. The basic educational problem is to comprehend these limits so that we may go beyond them.

3. Current Computer Software - It should be no surprise that computer programs have been developed by following the cookbook method. The minor programs are those that heavily concentrate on a single analytic method. These are too numerous to mention but any glimpse at a recent edition of "Educational and Psychological Measurement" or "Applied Statistics" will show entire sections devoted to this variety of singletons. The most popular minor programs are then lumped together in the form of "packages" where (sometimes) each individual variety of analysis is placed in a common "language" base. A good example of these major programs is the BMDP series (Dixon, 1977). One common result of this programming style is that a researcher can attempt to use an analytic method that he/she knows absolutely nothing about. In fact, it is entirely possible to run many varieties of analyses without knowing anything about the assumptions or estimation techniques used by any of them.

This should not all be seen in a negative light. These programs and comparisons can do a great deal in the way of pedagogy. The problem is that we are then constrained in our analytic thinking to those cookbooks which we have available. The purpose seems to be to develop easier to use software at the expense of the validity of the software itself (cf. ASA Report, 1977).

4. An Alternative Approach - Suppose we begin by rejecting the notion that all of these methods are to be used in very specific design situations. Instead let us approach this with the general abstract principle that we wish to elucidate relationships among the variables we have measured and the constructs they supposedly represent. Secondly, we wish to examine the relationships among those constructs. We wish to be able to conceptualize all forms of data in this fashion regradless of numerosity or scaling. In the next section we will present a general model which exhibits some of these virtues. Perhaps the best example is R. Darrell Bock who has started much work in this area through the International Educational Services (IES). IES offers the most comprehensive up-to-date multivariate software in the form of methods for the analysis of qualitative data in MULTIQUAL (Bock and Yates, 1977), quantitative data in MULTIVARIANCE-VI (Finn, 1977), and Linear Structural Relations with LISREL-IV (Jöreskog and Sörbom, 1978). Bock himself envisions the merger of MULTIQUAL and MULTIVARIANCE in one package called MULTISTAT (R.D. Bock, personal communication, November, 1978). The approach taken in this paper is that a LISREL-like model can be used as a global representation of all of these models. The end-state of this effort is to provide a model that will be general enough to be worth the cost of software development. In the following sections we will describe the preliminary development of this conception.

II. MOSAN - A "New" Model for Moment Structure Analysis

1. Introduction - In this section we will develop the basic philosophy of the Moment Structure Analysis (MOSAN) Model. MOSAN is termed "New" because, as will be shown in a later section, it is novel in a rather paradoxical sense. That is, MOSAN is a direct derivation of the models developed by Keesling and Wiley (1975), Jöreskog and Sörbom (1977) McDonald (1978), and Bentler (1976). MOSAN is paradoxical in the fact that it includes all of these models as special cases while in itself it is also a special case of all of these other models. The basic motivation for the use of MOSAN rather than these others stems from the fact that it is conceptually simpler and easier to understand than any of these seemingly more complex models. At the same time MOSAN serves as both a scientific and a calculation model (Cattell, 1978). This presentation will deal with MOSAN under the strict assumptions of parametric linear relations. However, MOSAN is not conceptually limited to these notions about the nature of data.

Since we will run across the terms "model" and "parameter" it is best to define each in advance. Excellent presentations of these ideas are available in Vemuri (1978) and Cattell (1978) but will be briefly described here . A parameter is a single, sometimes unknown element of a structural theory. As its' name implies it is used to restrict the permissable values of a formal operation. In this way a parameter limits the field of possible observables into those (few) that are consonant and those (many) that are dissonant with that parameter value. A formal model is the representation of theory in a structural form by the explicit definition of a full system of parameters. This can also be construed as the construction of a formal mathematical model which limits the permissable values of a system of formal operations into those (few) that can be considered to be consistent with the model and those (many) that cannot be considered to be consistent with the model.

Additional model definitions are important and are presented in later sections. However, it is wise to further distinguish a few basic model conceptions. A calculation model is simply a set of formal rules by which we may estimate the values of parameters. This usually occurs under a given formal model and for a specific set of observables. A scientific model is a theoretical system of parameters based upon substantive ideas and information. These may have little relation to the available calculation models. The process of Model Building is considered here to be the creative merger of the scientific model substance with the calculation model limitations. This effort fundamentally begins with the scientific substance raising questions and then requiring formal expression of answers in a calculation schema. In this regard the MOSAN model to be described is seen as a very general calculation model whose basis is designed for use in a general scientific framework. MOSAN is not simply to be used to calculate parameters but to facilitate this merger of model building by structuring scientific inquiry.

2. Basic Data - Let us assume we have measured G independent groups of N individuals on P measures. We then arrange each of these groups into a Raw Data matrix. The gth group of n subjects on p measures is described:

1) $\underset{(nxp)}{Y^{(g)}}$

Further, let us assume that each raw data matrix is completely described by the first two moments of its' distribution (i.e. the mean and covariances). This, in particular, is true if we make the distributional assumption of multivariate normality (Anderson, 1958). We may then calculate the Moment matrix for each group as the expected value (E) of the sample weighted cross-products matrix

2) $E(Y^{(g)t}\, Y^{(g)}\, n^{(g)-1}) = \Pi^{(g)}$

The Moment matrix is decomposable under these assumptions into the sum of the stochastically independent Mean matrix μ and Covariance matrix Σ

3) $\underset{(pxp)}{\Pi^{(g)}} = \underset{(px1)}{\mu^{(g)t}}\, \underset{(1xp)}{\mu^{(g)}} + \underset{(pxp)}{\Sigma^{(g)}}$

Thus, for each group, there are $p(p+1)/2$ covariances (since Σ is square and symmetric) and p means. So, in a full MOSAN model there will be

4) $G\{[p(p+1)/2]+p\}$

independent pieces of information in all of the moment matrices.

In order to facilitate notation we will now drop the g superscript. It is important to understand that each equation is implicitly defined for each group separately.

The previous equations may be developed in a somewhat more conventional framework. First, the overall expected value is:

5) $$E(Y) = \underset{(nx1)}{1} \; \underset{(1xp)}{\mu}$$

where 1 is a n-length vector of ones. The covariances are now describable as:

6) $$\Sigma = E[(Y-\mu)^t (Y-\mu)\eta^{-1} = \Psi \, \Sigma_\rho \, \Psi$$

where Φ equals a diagonal matrix of population variances and Σ_ρ refers to the symmetric matrix of population variances. We now speak of the Level (μ), Scatter (Ψ), and Shape (Σ_ρ) of G groups (Horn, 1969).

3. Covariance Σ with MOSAN Λ, Ω, and Φ - The first fundamental MOSAN conception is that the p observed/manifest variables can be described as linear functions of some q unobserved/latent variables. Assuming $\mu=0$

7) $$\underset{(nxp)}{Y} = \underset{(nxq)}{\eta} \; \underset{(qxp)}{\Lambda^t}$$

We note that q can be greater than p and is so in most applications. Each centered observed score Y is described in terms of q centered unobserved scores by the transitional matrix Λ. This system is termed the Measurement System and Λ is termed the Measurement matrix because this describes the process by which we provide a basis of measurement for the unmeasured variables η.

The second fundamental conception is that the η themselves are linearly related to one another. This may be represented as

8) $$\eta_i \, \omega_{ij} = \eta_j$$

In matrix notation

9) $$\underset{(nxq)}{\eta} \; \underset{(qxq)}{\Omega} = \underset{(nxq)}{\eta}$$

or, equivalently,

10) $$\eta = \eta \, \Omega^{-t}$$

where the superscript "-t" stands for "the inverse transposed". This, of course, assumes that Ω is square and non-singular but need not be symmetrical. Typically, however, each diagonal element of Ω equals 1. This is the basic Structural System and Ω is termed the Structural Matrix because it describes the structure of the relations among the η.

Under these conditions we may rewrite the two systems into one specification equation.

11) $$Y = \eta\ \Omega^{-t}\ \Lambda^{t}$$

Although Equation 11 cannot be verified directly in any dataset the structure of Σ can be verified in the sample covariances S. The Σ representation of MOSAN is now:

12) $$\begin{aligned} \Sigma &= E(Y^{t}Y_{n}^{-1}) = (\eta\ \Omega^{-t}\ \Lambda^{t})^{t}\ (\eta\ \Omega^{-t}\ \Lambda^{t}) \\ &= (\Lambda^{t})^{t}\ (\Omega^{-t})^{t}\ (\eta)^{t}\ \eta\ \Omega^{-t}\ \Lambda^{t} \\ &= \Lambda\ \Omega^{-1}\ \eta^{t}\ \eta\ \Omega^{-t}\ \Lambda^{t} \end{aligned}$$

The third MOSAN fundament is the possibility of some remaining covariance among the η above and beyond the structural system.

13) $$E(\eta^{t}\eta) = \underset{(q\times q)}{\Phi}$$

This Φ is termed the Unexplained System because it represents covariance among the Y that is embedded into the full model but is not truly explained in terms of either the measurement or structural system. We can now rewrite Equation 12 as the full MOSAN model for the covariance structure in terms of the:

i) Measurement Matrix Λ
ii) Structural Matrix Ω
iii) Unexplained Matrix Φ, as

14) $$\underset{(p\times p)}{\Sigma} = \underset{(p\times q)}{\Lambda}\ \underset{(q\times q)}{\Omega^{-1}}\ \underset{(q\times q)}{\Phi}\ \underset{(q\times q)}{\Omega^{-T}}\ \underset{(q\times p)}{\Lambda^{T}}$$

This Σ structure will be all that is necessary for covariance structure analysis. In these and other cases we require the computational practice of being able to specify constraints or restrictions on any element in any or all of the parameter matrices. In general we will desire a solution to a particular problem to be found where we allow any element in Λ, Ω, and/or Φ to be either

1) free - to be estimated,
2) fixed - to be equal to some known value, or

3) constrained - to be equal to some function of other model parameters.

The clearest example of this type of parameterization will be the imposition of fixed zero or fixed one to define a specific model. This will be explained in detail in a leter section.

4. Mean μ with MOSAN θ - The fourth basic MOSAN principle is that the mean of the observed variables may be represented as linear functions of the means of the unobserved variables η.

15) $$\underset{(n\text{x}q)}{E(\eta)} = \underset{(n\text{x}1)}{1} \quad \underset{(1\text{x}q)}{\theta}$$

Using Equation 11 we may then describe the manifest variable means by substitution in the expected value of the latent variables

16) $$E(Y) = \underset{(n\text{x}1)}{1} \quad \underset{(1\text{x}q)}{\theta} \quad \underset{(q\text{x}q)}{\Omega^{-t}} \quad \underset{(p\text{x}p)}{\Lambda^{t}}$$

or, equivalently

17) $$\mu = \theta\ \Omega^{-t}\ \Lambda^{t}$$

This simply suggests that the p manifest means are described by the q latent means. This description is linear in exactly the same fashion as the Σ due to the presence of the same Ω and Λ. However, as before, we will allow for fixed, free, and constrained elements in θ. Using this principle there is no loss of generality when the μ are structured in the same fashion as Σ because we may set structural zeros to separate both effects. For example, we can use super-matrix partitioning to create separate μ and Σ as presented in Equation Set 1. Here the μ are structured independently of the Σ. Thus, the linear fashion in which the unobserved θ are related to the observed means is not necessarily dependent on the Σ. The interested reader should see McArdle (1978) for a substantive example of this type.

5. MOSAN Structure - A structural diagram of the previous equations will help to explicate the MOSAN model. Some MOSAN diagrammatic notation is a prerequisite. Here, squares will represent observed variables Y and triangles their means $\bar{Y}$. Correspondingly, the circles will represent the unobserved variables η and ovals their means θ. A solid one-headed arrow will represent

Equation Set 1: The Separation of Σ and μ in MOSAN

Letting:

$$\eta = \begin{bmatrix} \eta_\Sigma & \eta_\mu \end{bmatrix}$$

$$\Lambda = \begin{bmatrix} \Lambda_\Sigma & \Lambda_\mu \end{bmatrix}$$

$$\Omega = \begin{bmatrix} \Omega_\Sigma & 0 \\ 0 & \Omega_\mu \end{bmatrix}$$

$$\Phi = \begin{bmatrix} \Phi_\Sigma & \text{Sym} \\ 0 & 0 \end{bmatrix}$$

$$\Theta = \begin{bmatrix} 0 & \Theta_\mu \end{bmatrix}$$

Then :

$$\Sigma = \Lambda_\Sigma \, \Omega_\Sigma^{-1} \, \Phi_\Sigma \, \Omega_\Sigma^{-t} \, \Lambda_\Sigma^{t}$$

$$\mu = \Theta_\mu \, \Omega_\mu^{-t} \, \Lambda_\mu^{t}$$

a direct structural path in the direction of the arrow head. The value placed on this path will represent the value of that structural parameter. A dotted one-headed arrow will represent a variance term associated with an unobserved variable and a dotted-two-headed arrow will denote a covariance among unobserved variables. Using this notation Figure 1 presents the full MOSAN model given by Equations 14 and 17.

This pictorial demonstration portrays the simplicity of MOSAN and, at the same time, provides an accurate representation of the MOSAN equations. Here we have observed variables Y and unobserved variables η. Their direct connection is via the Measurement System matrix Λ. We now see that the elements of Λ, the λ_{ij} are regression weights for the η_j onto the Y_i. The Structural System matrix Ω, and its' elements ω_{jk}, are regression weights for the η_k onto the η_j. The Unexplained System matrix Φ, and its' elements ϕ_{jk} represent covariances, or correlation rather than regression coefficients, among the η_j and η_k that are not explained by the Ω Structural System. Finally, the sample means $\bar{Y}$ are described in the same linear fashion as the sample covariances S with the latent means θ. Most importantly, all of the direct observable relations between the Y, inherent in S and $\bar{Y}$, are explained in terms of the relations of η and θ embedded in Λ, Ω, and Φ. To calculate the covariance among the Y for any hypothesized model one can simply use path analytic rules (cf. Li, 1975) or calculate the full MOSAN Σ in Equation 14. Figure 2 presents MOSAN in a schematic form used to simplify pictorial representation. Note that more than one group is possible.

6. Disturbance Variables in MOSAN - As noted before, a key feature of any estimation technique used is the necessary condition of the specification of fixed, free, and constrained parameters. This is crucial when structuring linear regressions in the compact MOSAN fashion because we may wish to consider disturbance terms in all equations. Assumming that a linear regression in either Λ or Ω does not completely account for the variation in the outcome or dependent variable we will wish to create Disturbance variables ζ. The ζ are simply to be considered as special types of latent variables η. There are three special disturbance rules in this regard

(1) ζ has only one non-zero relation with Y in Λ or η in Ω and this relation is fixed at a regression weight of one.

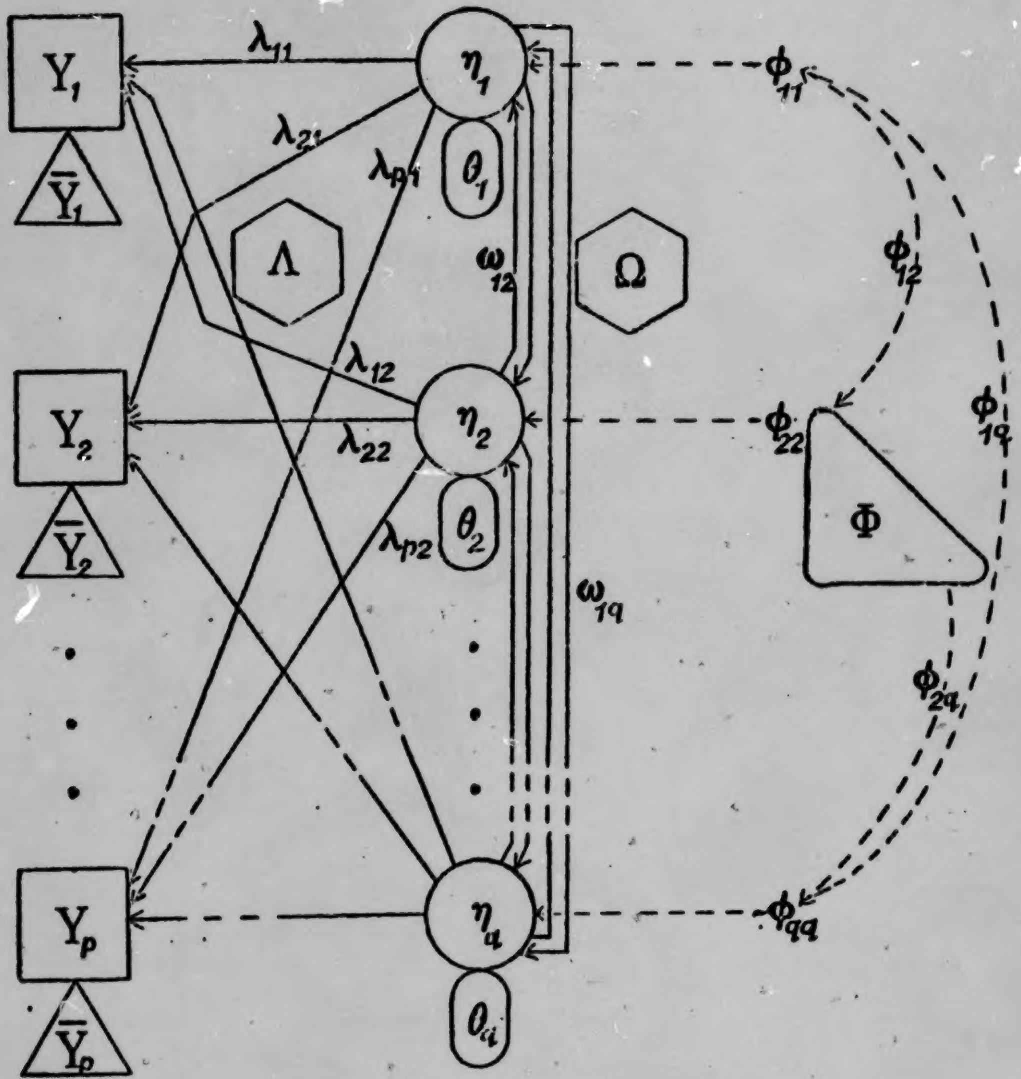

Y_1
$\bar{Y}_1$
Y_2
$\bar{Y}_2$
Y_p
$\bar{Y}_p$
λ_{11}
λ_{21}
λ_{p1}
λ_{12}
λ_{22}
λ_{p2}
Λ
η_1
η_2
η_q
θ_1
θ_2
θ_q
ω_{12}
ω_{1q}
Ω
ϕ_{11}
ϕ_{12}
ϕ_{1q}
ϕ_{22}
ϕ_{2q}
ϕ_{qq}
Φ

Figure 1: The Moment Structure Analysis (MOSAN) Model for one group (G = 1)

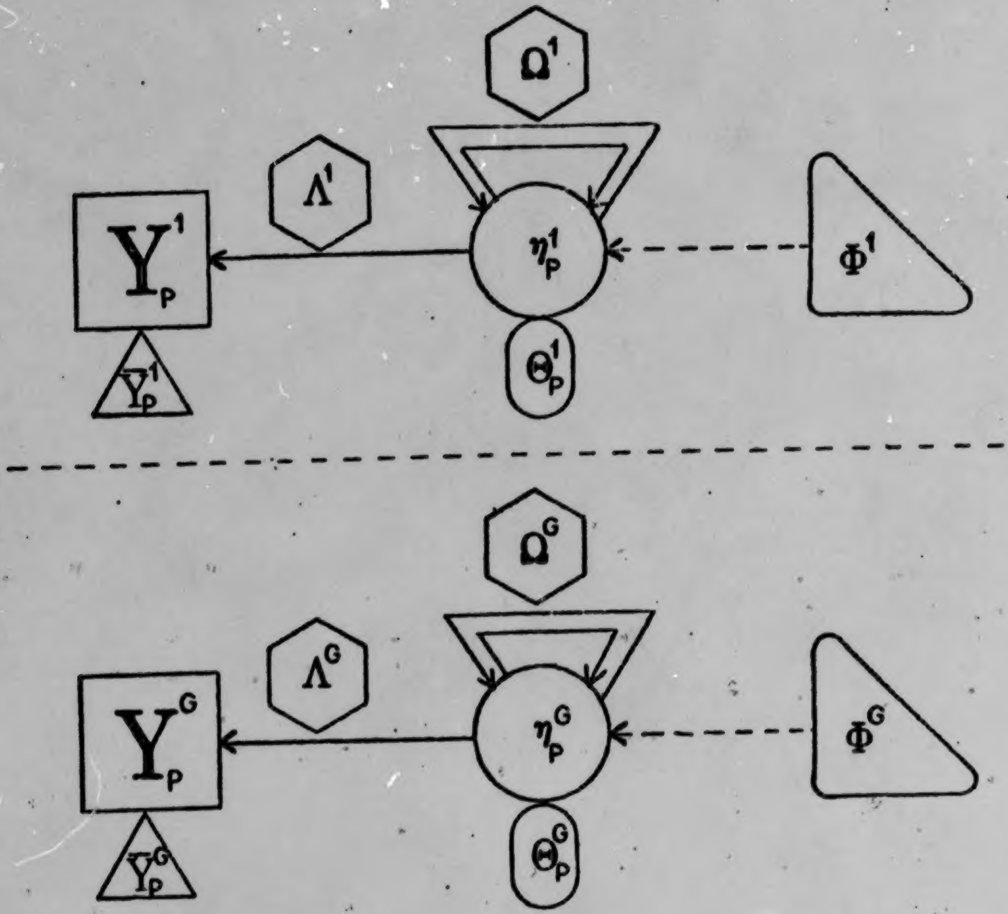

Ω^1
Λ^1
Y_P^1
η_P^1
Φ^1
$\bar{Y}_P^1$
Θ_P^1
Ω^G
Λ^G
Y_P^G
η_P^G
Φ^G
$\bar{Y}_P^G$
Θ_P^G

Figure 2: A Schematic View of the Full MOSAN Model

(2) ζ has variance in Φ but no covariance with any other η. These disturbance variables are thus assumed to be uncorrelated with other model components but may be correlated with themselves in special cases.

(3) $E(\zeta) = 0$

We consider these ζ to add information to the full model only in the form of the unexplained variance Φ. Thus, ζ represent singular random influences only. Typically in the Measurement System these are termed "Errors of Measurement" and in the Structural System these are termed "Errors in Equations".

7. Estimation, Identification, and Testing - The actual estimation for the simple MOSAN is a rather complex issue. In simplest terms we can solve these equations by

(1) Defining necessary model conditions for identification--assuring that each and every parameter to be estimated is not simply a linear function of other parameters to be estimated.

(2) Describing an error function to be minimized-typically either a version of Weighted Least Squares or Maximum Likelihood.

(3) Solve this minimum problem in an iterative algorithmic fashion--due to the fact that the equations are typically not of closed form.

The technical details for various estimation procedures are presented in the Appendix. It should be noted that the approach followed here is heavily dependent on the pioneering work of Sörbom (1974, 1978) and Jöreskog (1971, 1977). Exact similarities to their models will be presented in a later section.

I have not described much about how to specify the necessary model conditions for identification. Although this is difficult in complex situations it is relatively easy in others. Two conditions of importance follow

(1) Order - We only have information in the observed means and covariances for the groups as expressed by Equation 4. We cannot obtain an identified model if we try to estimate more parameters than we have observables.

(2) Rank - We cannot estimate parameters that are linear functions of other parameters that we wish to estimate. This causes a singularity

> in matrix inversion or a Rank 1 condition. This can occur even if we have met the Order Condition while, conversely, the Order Condition cannot occur if we have met the Rank Condition.

More detailed versions of these ideas are available in Jöreskog (1977) and McDonald and Krane (1978). It seems best to deal with these problems as they arise in a specific model and we will do this in later sections.

The basic philosophy behind MOSAN model testing is well described by Meehl (1978) and Pitz (1978). We do not wish to "fit a model to data" but rather we wish to "compare the goodness-of-fit of various models". In order to make such comparisons we require an explicit representation of at least two hypothesized models. In the strictest sense, the first model should have z parameters to estimate and the second should be posed as an alternative with one of the first z parameters either fixed or constrained, yielding z-1 parameters to estimate. The comparison of the goodness-of-fit between these models tests the adequacy of the fixed or constrained parameter under the general framework of the rest of the model. Let the first model be the hypothesized (h) model and the second be the alternative (a) model. Then, the degree of information available in this form of testing takes on the following generic form. Let the degrees of freedom in any model (m) be described as:

18) $$DF_m = G\{\, p(p+1)/2 - R(\Lambda, \Omega, \Phi) + p - R(\Theta)\}$$

Here $R(\Lambda, \Omega, \Phi)$ is the number of model restrictions placed on the elements of Λ, Ω, and Φ, and $R(\Theta)$ is the number of model restrictions placed on the Θ. This can be seen as the sum of residual covariance and mean information:

The important model comparison can now be considered in terms of informational content as degrees-of-freedom for comparison (c).

19) $$DF_c = DF_a - DF_h$$

Under certain forms of model estimation, such as Generalized Least Squares (GLS) and Maximum-Likelihood (ML) large sample chi-square (χ^2) statistics can be applied to this model comparison in the same fashion. However, the important point here is that testing is viewed only in terms of a comparison between explicitly defined models.

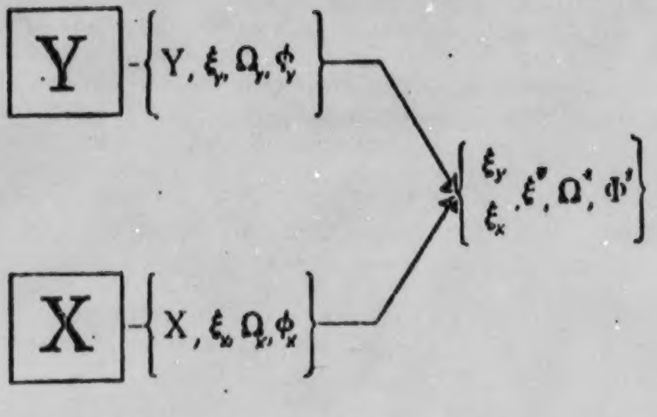
III. MOSAN Among Others

1. Introduction - In this section we will illustrate a few basic principles of the most general multivariate analytic techniques through MOSAN structural representation. The important point here is that MOSAN is a simple conceptual system for thinking about scientific theory. Other models of this variety are complex and confusing. MOSAN places all of these under one general framework and teases out the complexity of their interrelationships.

2. Canonical Correlation - An extremely general parametric calculation model is that of Canonical Correlation (CC-cf. Bock, 1975; Skinner, 1977). The basic CC eigenvalue equations reflect the very heart of most multivariate/univariate models. Figure 3 presents a schematic view of a canonical analysis of the interrelationship of set Y and X. These can be seen in the sequential fashion of 1) calculating the Truncated Principal Components (PC) within each set X and Y, yielding components ξ_x and ξ_y, and 2) calculating the PC between X and Y, or within ξ_x and ξ_y, yielding CC ξ^*. The maximization of PC is an attempt to sequentially create ξ_i with maximum variance Φ_i and then use residuals from this to create ξ_{i+1} with maximum Φ_{i+1}. As it turns out the CC correlation is exactly the variance of ξ^* minus 1, or $\Phi^* - 1$. Skinner (1977) shows this result in a slightly different fashion. The main criticisms of this model follow.

1) The conception of "error" is totally embedded in global residuals since all equations are perfect linear combinations.
2) The philosophical point of view of the creation of ξ is "non-epistemic" therefore assuming that the Y's and X's underly or create the ξ rather than the reverse view which is predominant in most behavioral science theory (Coan, 1964).
3) The use of "residual" analysis makes the model hopelessly inestimable using simultaneous methods unless special side conditions are imposed.

In short, CC is seen as a very useful calculation model under certain side conditions but has little promise


Y
{Y, ξ_y, Ω_y, φ_y}
X
{X, ξ_x, Ω_x, φ_x}
{ξ_y ξ_x, ξ*, Ω*, Φ'}

WHERE

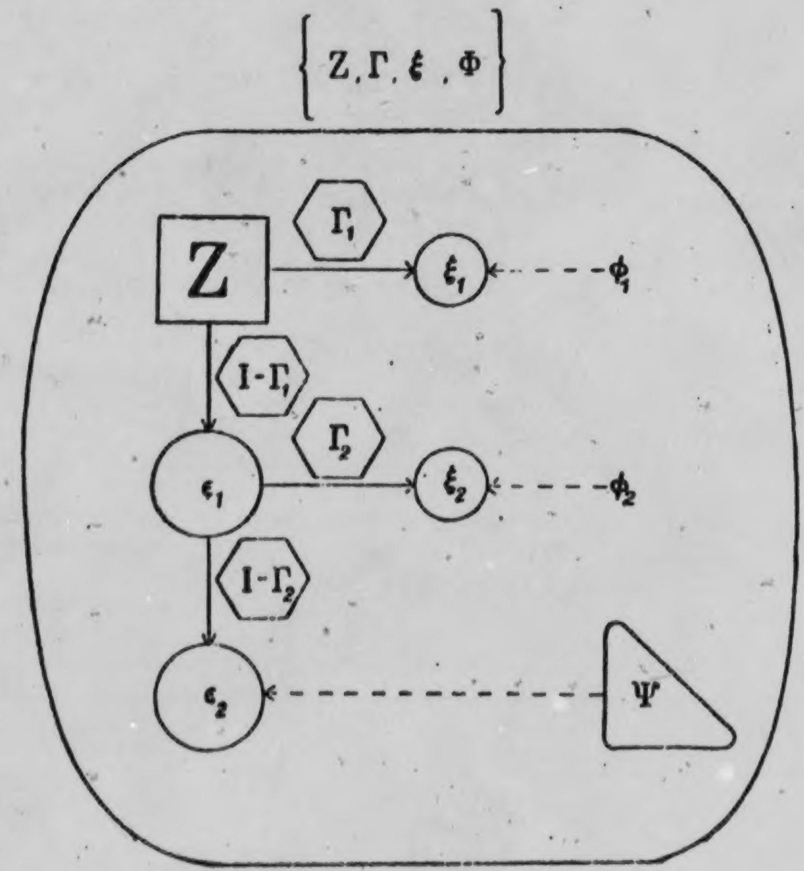

{Z, Γ, ξ, Φ}
Z
Γ1
ξ1
φ1
I-Γ1
Γ2
ε1
ξ2
φ2
I-Γ2
ε2
Ψ

Figure 3: The Canonical Correlation (CC) Model

as a method for science. As mentioned before, we can see a wide variety of multivariate methods subsumed by CC. For example, if we have G=3 groups measured on p=2 tasks and we run a MANOVA the resultant Ω^* and ϕ^* are numerically identical to a CC with the two tasks as Y and two dummy coded contrasts as X. In MANOVA we attempt to create a component with largest variance ϕ^* which itself is comprised of some large components of the tasks and some large components of the group difference variation. Here we must assume that the Σ composition of each group is identical, as well as the Ω^*. None of these assumptions are required of a MOSAN analysis of separate group μ and Σ. The latent ξ may be created as a linear combination of observables, or perhaps epistemically. These Λ and/or Ω^* can be constrained to be identical over groups. The Λ can include a full measurement system and/or Ω^* a full structural system. The μ can be tested for equality over groups or as fixed at zero. Interaction can be defined as the necessity of not constraining a parameter over groups, or in some more complex form. The lesson here is that the general CC model is not the only way to go. On a scientific basis several others may seem much more reasonable.

4. Linear Structural Relations - Throughout this discussion we have been pointing out the limitations of the CC method in regard to MOSAN possibilities. We now turn to a model that we will not criticize for it's limitations but for it's oversight of MOSAN simplicity. The model we are now discussing is the LISREL-IV model of Jöreskog and Sörbom (1978). This model is relatively new but is currently enjoying a wide audience in the behavioral sciences. The schematic view of LISREL presented in Figure 4 will illustrate the great flexibility of this model. Here we have two sets of variables Y and X. Neither of these sets are perfect measures of the constructs that we wish to tap so we assume a (COFAMM-like) factor model for each. The k latent constructs for Y are termed η and the m latent constructs for X are termed ξ. The disturbance variables ε and δ are assummed to have unit relation with the respective manifest variables and covariance Θ_ε and Θ_δ. These are the Measurement Systems. These latent variables are themselves interrelated with epistemic Γ from ξ to η, B showing linear relations among

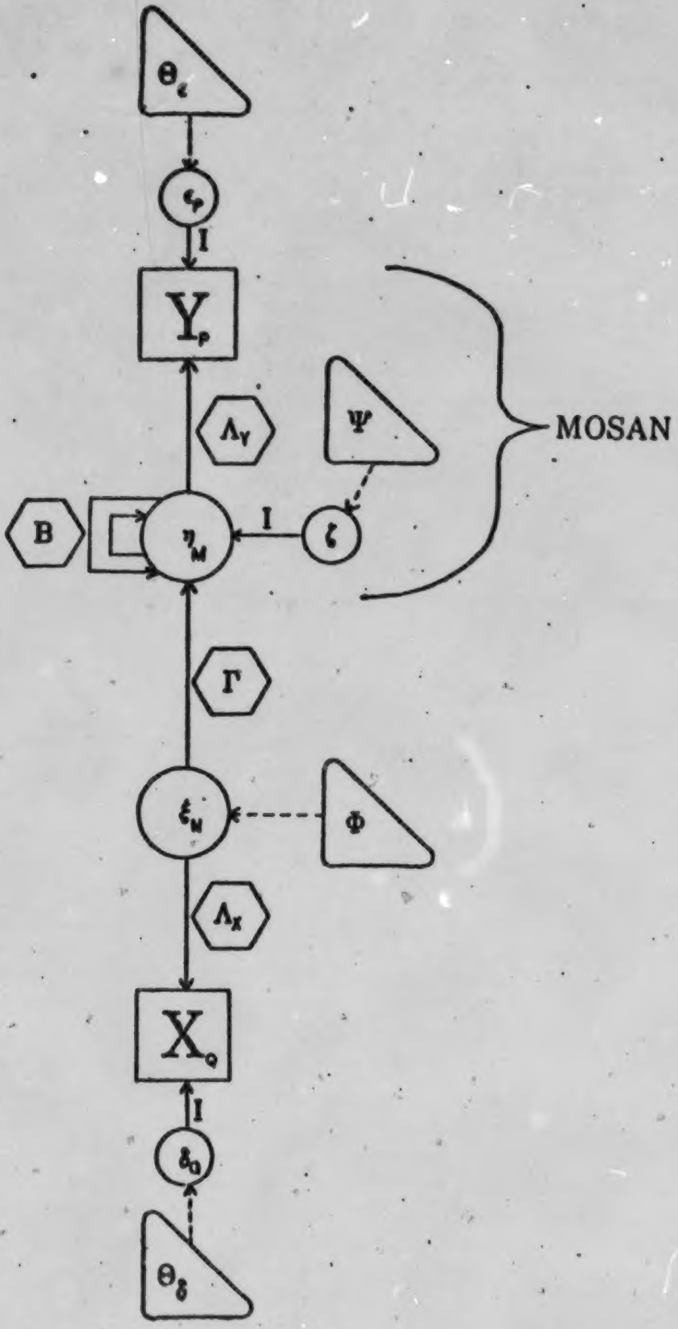

Θ_ε
ε_p
I
Y_p
Λ_Y
Ψ
MOSAN
B
η_M
I
ζ
Γ
ξ_M
Φ
Λ_X
X_Q
I
δ_Q
Θ_δ

Figure 4: The Linear Structural Relations (LISREL) Model with sub-model MOSAN (G = 1)

Equation Set 2: The LISREL Model (only one group presented)

Equations:

$$\underset{(nxp)}{Y} = \underset{(nxk)}{\eta} \; \underset{(kxp)}{\Lambda_y^t} + \underset{(nxp)}{\varepsilon}$$

$$\underset{(nxq)}{X} = \underset{(nxm)}{\xi} \; \underset{(mxq)}{\Lambda_x^t} + \underset{(nxq)}{\delta}$$

$$\underset{(nxk)}{\eta} \; \underset{(kxk)}{B^t} = \underset{(nxm)}{\xi} \; \underset{(mxk)}{\Gamma} + \underset{(nxk)}{\zeta}$$

Disturbances:

$$E(\zeta^t\zeta) = \Psi$$

$$E(\varepsilon^t\varepsilon) = \Theta_\varepsilon$$

$$E(\delta^t\delta) = \Theta_\delta$$

Covariances:

$$\Sigma = \begin{bmatrix} \Sigma_{yy} & \mathrm{Sym} \\ \Sigma_{yy} & \Sigma_{xx} \end{bmatrix}$$

$$\Sigma_{yy} = \Lambda_y \; (E(\eta^t\eta)) \; \Lambda_y^t + \Theta_\varepsilon$$

$$E(\eta^t\eta) = B^{-1} \; (\Gamma \; \Phi \; \Gamma^t + \Psi) \; B^{-t}$$

$$\Sigma_{xx} = \Lambda_x \; (E(\xi^t\xi)) \; \Lambda_x^t + \Theta_\delta$$

$$E(\xi^t\xi) = \Phi$$

$$\Sigma_{xy} = \Lambda_y \; \Phi \; \Gamma \; B{-1} \; \Lambda_y^t$$

Equation Set 3: MOSAN in LISREL

Equations:

$$\underset{(n\times p)}{Y} = \underset{(n\times q)}{\eta} \quad \underset{(q\times p)}{\Lambda_y^t}$$

$$\underset{(n\times q)}{\eta} \quad \underset{(q\times q)}{B^t} = \underset{(n\times q)}{\eta}$$

Covariances:

$$\Sigma = \Sigma_{yy} = \Lambda_y \ (E(\eta^t \eta)) \ \Lambda_y^t$$

$$E(\eta^t \eta) = B^{-1} \ \Psi \ B^{-t}$$

Equation Set 4: LISREL in MOSAN

$$Y^t = \begin{bmatrix} Y & X \end{bmatrix}$$

$$\eta^t = \begin{bmatrix} \zeta & \eta & \varepsilon & \xi & \delta \end{bmatrix}$$

$$\Lambda = \begin{bmatrix} 0 & \Lambda_y & I & 0 & 0 \\ 0 & 0 & 0 & \Lambda_x & I \end{bmatrix}$$

$$\Omega = \begin{bmatrix} I & 0 & 0 & \Gamma & 0 \\ I & B & 0 & 0 & 0 \\ 0 & 0 & I & 0 & 0 \\ 0 & 0 & 0 & I & 0 \\ 0 & 0 & 0 & 0 & I \end{bmatrix}$$

$$\Phi = \begin{bmatrix} \Psi & & & & \text{Sym} \\ 0 & 0 & & & \\ 0 & 0 & \Theta_\varepsilon & & \\ 0 & 0 & 0 & \Phi & \\ 0 & 0 & 0 & 0 & \Theta_\delta \end{bmatrix}$$

$$\Theta = \quad 0$$

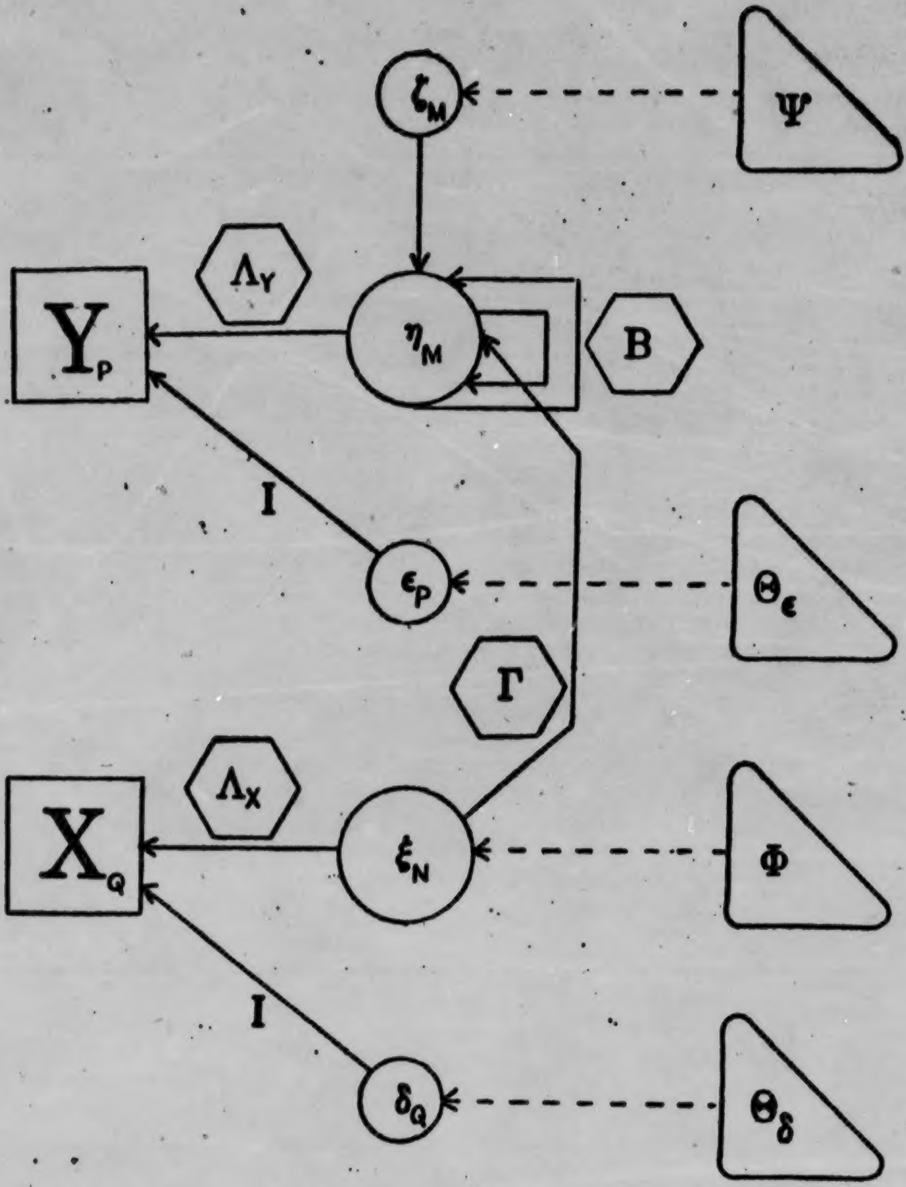

ζ_M
Ψ
Λ_Y
Y_P
η_M
B
I
ϵ_P
Θ_ϵ
Γ
Λ_X
X_Q
ξ_N
Φ
I
δ_Q
Θ_δ

Figure 5: The LISREL Model as a sub-model of MOSAN (G = 1)

the η, and ζ the disturbance variables with covariance Ψ. The ξ are allowed to covary in Φ. The specific equations for this are presented in Equation Set 2. Here we see the complexity of the parameterization with eight matrices but due to the great flexibility of this model we see its' value as a scientific conception.

The relation between LISREL and MOSAN is paradoxical. While at this time G groups are allowed mean structuring is not. This is a simple problem that will be overcome in LISREL-V (D. Sörbom, Pers. Comm. Sept., 1978) and is not of major importance here. In the examination of Figure 4 we can view all of the necessary matrices for a MOSAN analysis. By simply setting $\Lambda = \Lambda_y$, $\Omega = B$, and $\Phi = \Psi$ we can extract MOSAN from LISREL. The only confusion here will be in the use of Ψ as a full matrix for all η rather than just those of ζ. Here we observe a MOSAN characteristic. When $\Omega \neq I$ the only elements of Φ are those associated with an η that has ζ characteristics (see Section II.6). Alternatively, when $\Omega = I$ the Φ are possible on all η. This entire point is illustrated in Equation Set 3 whence MOSAN is derived as a subset of LISREL.

At this time things appear simple. MOSAN is a subset of the more general LISREL structure. This, however, is not the only way to look at this for LISREL is also a subset of MOSAN! Figure 5 displays the structural representation of this concept and Equation Set 4 verifies the mathematics. As both presentations show we are now working with large sparce matrices. However, the key point in this is the very basis of the MOSAN model.

1) We have linear relations between observed and unobserved and these are represented in a Measurement System.
2) The η and ξ are constructs of epistemic value with Y and X.
3) The ε and δ are errors of measurement that contribute only to unexplained variation
4) ζ are errors on equations, have no direct relation to observables, and contribute only to unexplained variation.
5) The Γ and B represent structural relations among the latent variables only.
6) The covariation in ξ is not explained by the model.

At very least, this view of LISREL helps in the understanding of the complex equational system. Some important LISREL variations such as models for longitudinal data (Jöreskog and Sörbom (1977) can, and will, be much more easily developed using the three system/matrix MOSAN conception. Of course, the paradox is that one can view either as subsets of one another.

5. Higher-Order Models - Perhaps the most general model yet presented is Bentler's (1976) Multistructure (MULSTR) Model. In general MULSTR may be described by a hierarchy of latent variables with structured means. Bentler's (1976) presentation was designed to provide a scientific conception and many calculational details were not given. However, McDonald (1978) under a slightly different framework, presents the necessary calculation treatment as a subset of his general model COSAN. Each of these will be discussed in turn.

Figure 6 displays the MULSTR model in schematic form and Equation Set 5 in equation form. While the equations are rather complex the structural diagram is rather simple. Here we see the latent variables ξ_1 having direct relations to the manifest X. The other ξ_m each relate sequentially to one another with their transitional matrix Δ_m. Additionally, there is unknown covariance at each step in this sequence, here termed Ψ_m. This is an extremely general model which can be used to structure a variety of multivariate methods. However, MULSTR basis seems most akin, from a scientific framework, to a hierarchy of factors. Cattell (1978) recognizes this idea as a powerful conceptual base with many real world implications. Bentler (1976) himself notes this when he shows how Jöreskog's (1973) Analysis of Covariance Structure (ACOVS) Model is simply a second-order factor structure. He shows how ACOVS is a subset of this model and how another formulation of basic factor analysis is possible under these considerations. All this is to say that MULSTR is extremely useful. Of course, it has been drawn to provide direct representation as a subset of MOSAN. The equational form of this direct similarity is given in Equation Set 6. While the mean vector is not presented in Figure 6 its' direct similarity is described in these equations also.

Bentler and Weeks (1978) show how many other models, including LISREL, can be considered subsets of MULSTR.

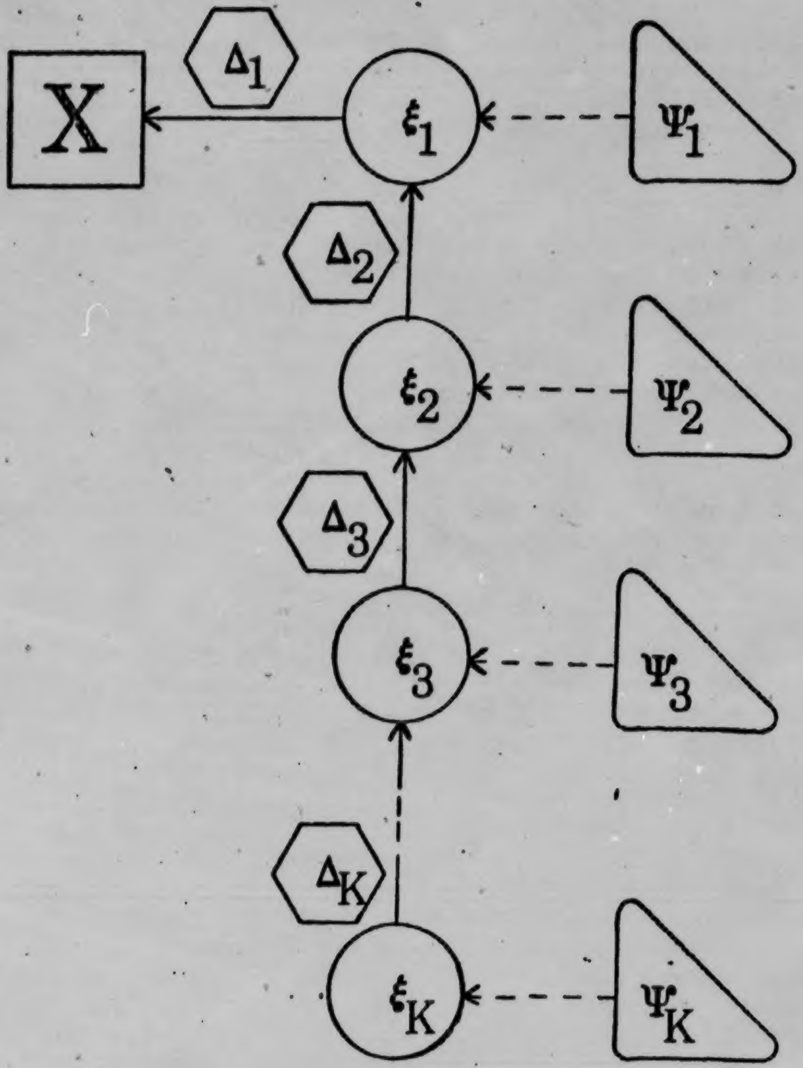

X
Δ_1
ξ_1
Ψ_1
Δ_2
ξ_2
Ψ_2
Δ_3
ξ_3
Ψ_3
Δ_K
ξ_K
Ψ_K

Figure 6: The Multistructure (MULSTR) Model as a sub-model of MOSAN (G = 1)

Equation Set 5: The Multistructure Model (MULSTR)

To facilitate notation we have let Bentler's (1976) $\Lambda_i = A_i$ and $\Phi_j = T_j$ and $G = 1$. Following Bentler and Weeks (1979) we let Π be the product operator and write:

Vector:

$$X = \mu + \sum_{j=1}^{k} \left(\prod_{i=1}^{j} A_i \right) \xi_j$$

Mean:

$$E(X) = \mu = \gamma \Xi U + V \Omega W$$

where U, V, and W are fixed

Covariance:

$$\Sigma \quad \sum_{j=1}^{k} \left(\prod_{i=1}^{j} A_i \right) T_j \left(\prod_{i=1}^{j} A_i \right)^t$$

Equation Set 6: MULSTR in MOSAM

Covariances:

$$B = \begin{bmatrix} \xi_1 & \xi_2 & \xi_3 & \cdots & \xi_k \end{bmatrix}$$

$$A = A_1$$

$$B = \begin{bmatrix} I & A_2 & 0 & \cdots & 0 \\ 0 & I & A_3 & & 0 \\ 0 & 0 & I & & 0 \\ \vdots & & & \ddots & \vdots \\ \vdots & & & \ddots & A_k \\ 0 & 0 & 0 & \cdots & I \end{bmatrix}$$

$$\Phi = \begin{bmatrix} T_1 & & & \text{Sym.} \\ 0 & T_2 & & \\ 0 & 0 & T_3 & \\ \vdots & & & \ddots \\ 0 & 0 & \cdots & T_k \end{bmatrix}$$

Mean:

Following Weeks (1978) and using the mean and covariance separation of Equation Set 1:

$$\Theta = \begin{bmatrix} \gamma & V \end{bmatrix}$$

where we note the restrictions on Θ as a vector.

$$\Omega^{-1} = \begin{bmatrix} \Xi & 0 \\ 0 & \Omega \end{bmatrix}$$

$$\Lambda = \begin{bmatrix} U \\ W \end{bmatrix}$$

But if LISREL is a subset of MULSTR and MOSAN is a subset of LISREL, isn't MOSAN also a subset of MULSTR? Of course, the answer is a paradoxical "yes" once again. While MOSAN includes MULSTR, MULSTR includes MOSAN. This is evident when we include the possibility of a patterened inverse for one of the Δ_m. With this as a recursive possibility the $\Delta_2^{-1} = \Omega$ and $\xi_i = 0$ for $i>2$,we have MOSAN. Actually, McDonald (1978) provides this possibility in computational form. He creates a model (and program) based on a very similar conception to MULSTR. In fact, this COSAN model would be structured exactly the same way as MULSTR with $\Psi_1=\Psi_2=\Psi_3=0$ so all of the unexplained covariance goes at the very last stage Ψ_k. Thus, it appears that COSAN is a subset of MULSTR. However, this is not the way McDonald views it and he shows how MULSTR is a subset of COSAN. Since we have already seen how super-matrix partitioning can lead to this subset paradox we should not be surprised at McDonald's claim. The real COSAN contribution is the virtually limitless calculational flexibility available in his program (for G=1 and no means). McDonald lays the foundation for a wide variety of important models that will surely come to fore in the behavioral sciences. The work of Bentler (1976) and Weeks (1978) are examples of this effort.

IV. The Use and Creation of a MOSAN Algorithm

1. Introduction - In this section we will briefly discuss some of the ways that we envision MOSAN use. These ideas will then lead to some suggested ways in which such an algorithm should be conceived and developed. It is important to note that MOSAN is not yet available in computational form. The Technical Appendix suggests ways in which features of MOSAN can be used at this time but here we will discuss more general features.

2. The Spiral Nature of Research/Analysis - Of great importance to this venture is the fashion in which we conceptualize the ongoing process of data analysis. For this we call on Cattell's (1978) idea of research as an inductive-hypothetico-deductive (IHD) spiral and Tukey's (1978) distinction between exploratory and confirmatory data analysis.

Research/analyses are seen to be the formal expression of the continuous train of ideas and thoughts. The researcher does not start out blindly but "deduces" some ideas about a specific issue. This is then put to a formal test of "confirmation" with observable data. Regardless of the outcome of this test there is then the possibility of "inducing" information from this same dataset, although these ideas were not formally stated in advance, and may in fact bear little relation to the purposes behind the original data collection. This process now takes on the character of "exploratory" analyses on the dataset. Of course, the purpose of this approach is to yield new, hopefully more precise, notions about the status of the ideas from whence we can "deduce" more and develop new hypotheses to be tested. The research is characterized by an IHD spiral and the data analysis by an Explore/Confirm process. The general features of any general algorithm must recognize these principles of the scientific endeavor. Once again, we are concerned with the practical merger of scientific thought and calculation possibilities.

3. Confirmatory/Deductive Features - No real distinction has yet been made between the CC and LISREL-like methods in terms of directed testing of specific hypotheses. In this case the LISREL model far outweighs the CC model by allowing very exact tests of parameter patterns. The MOSAN calculations presented in the Technical Appendix extend LISREL to include tests on the

mean vectors. Of course, simpler derivation exists for special models but these can be transparent to the user. As presented in Section II, this is best thought of in terms of comparison between theoretical models. In this type of examination and under certain types of model estimation (ML and GLS) exact statistical tests are available for global and specific parameters. One difficulty here is the lack of information on these tests under distributional assumption failure that seems rather common in behavioral science data. To assist in examination here we may wish to use several varieties of estimation and distributions. Comparison between the tests and estimators in a single study may help examine the sensitivity of these tests. Another approach which is widely used in situations where statistical knowledge is lacking is the use of monte carlo simulation. Here we would make up hypothetical models based on random spins within specific constraints and use these as the standard upon which we evaluate our theoretical model. The work of Van Hemert (19 76) is notable in this respect. In any case, MOSAN is extremely functional in confirming a wide variety of theoretical models.

4. Exploration/Induction Features - The confirmatory/ deductive features are not the final statement in data analysis. Following Horn (1972):

> This illustrates a case where there might be hunches in advance about the causes of the supposed change, but the fact of lawful change is not dependent upon prior knowledge. The same lawful change can occur whether or not we have an hypothesis stipulating that it will occur. Whatever their virtues on other counts, mthods which are directed at testing more or less specific hypotheses have the limitation that they are not well-suited for the discovery of novel principles. (p. 161)

Sörbom (1975, 1978) discusses how to use a "derivative-fitting" series of model tests to explore novel features of the data. The very notion of using a large variety of confirmatory tests until we arrive at those few that "fit" best violates the statistical basis of the tests. Alternatively, this may allow the data to express itself. In fact, this is probably how current confirmatory studies are conducted. There is nothing wrong with this as long as we recognize that we are exploring. MOSAN can be used in this way.

An important problem with this type of model-fitting is the associated computer costs. Put bluntly, it is a quite expensive method to use unless very specific hunches limit the possibilities. Here several conventional multivariate methods may be used as preliminary investigation methods. Skinner (1977) reviews some important principles here. This must not be in an extremely general fashion or we will lose the "point of view" afforded by the previous model specification. In line with this thinking Wold (1975) has emphasized his NIPALS models as "soft" compared to the ML "hard" versions. Other methods along this line, such as Rozeboom's (1977) GLDA models, may provide the necessary computational assistance for MOSAN. The important point here is that a variety of model conceptions can be given to us by the data itself. As scientists we must not ignore novel information,especially if it is at variance with a previous body of knowledge. The MOSAN calculations may not be the best way to obtain this information. This does not suggest that the MOSAN conception has failed, merely that we may wish to use less expensive approximations in calculation.

5. Simulation in Research/Teaching - We have already suggested that monte carlo distribution sampling may help in the evaluation of parameter sensitivity in a single study. MOSAN also provides a full model for extremely complex monte carlo research in an extremely simple form. We can simply create population Σ and μ as Λ, Ω, Φ, and θ. From this we may either generate random vectors η or sample from Π directly. A wide variety of complex models may be described in this fashion and easily programmed for the important and much needed monte carlo research.

Another important use of simulation models is the explicit representation of behavioral theory (Lehman, 1977). When data is not available for testing, extremely complex theory may be described in MOSAN form. The data that is then simulated represents the direct representation of the theory in behavioral form. Advances in theory construction may be possible from this form of remote reasoning. However, this is a relatively new method and its' value to behavioral science research is still widely unknown.

A final, practical use for simulation is in data analysis training. Again, data is simulated from a very specific population representation. We may then examine the proper and improper use of various analytic methods in somewhat graphic fashion. In fact, each student may have their own randomly perturbed dataset from a common population base. Comparative exposition may help develop the difficult data analytic "insight" so important in any actual research effort. MOSAN should be used as a conceptual base for complex simulation.

6. The Proposed Algorithm - We have laid out some requirements for a MOSAN program in this section. We require some advanced iterative algorithmic structure for direct confirmatory hypothesis testing. We may use this in exploration by passing through a limited set of possible models or create a derivative fitting scheme. We would wish to include additional algorithms to allow purely exploratory phases. Finally, we wish to include the possibility of simulation for districution bases, monte carlo research, theory construction, and data analysis pedagogy. Some additional practicalities will be discussed here.

Following the lead of the major program packages the algorithm should be easy-to-use. This usually takes on the form of a "parser" which scans for keywords and keyvalues. Perhaps the best example of this logic is the MINITAB program (Ryan, et al., 1978). An English-language-like base can be used with very few strict input rules. Another important fearure is that MOSAN should be embedded in a series of routines that provide MOSAN with its' basic data of S (or Y) and $\bar{Y}$. Since there are a wide variety of "exploratory" techniques (McNeil, 1977) that can properly be used in, say, transfroming data before calculating S, we would hope to be able to provide this without unnecessary external program transfer. Again, the MINITAB program, perhaps merged with the ELFA program (McNeil, 1977) would prove useful here.

We note that MOSAN is describable in terms of four matrices. However, for any given application these matrices are large and sparce with many zero, identity, or diagonal sub-matrices. Provisions should be made for the simple input of these structures without an element-by-element notation. This can take on a sub-matrix definition followed by free-field element input in a LISREL-IV fashion.

In conclusion we would like the complete MOSAN model to

1) have confirmatory routines
2) have exploratory routines
3) have simulation routines
4) be part of a more general program package, such as MINITAB-II
5) provide for flexible model input.

This proposed algorithm described here will allow for practical evaluation of the MOSAN model developed in the earlier sections of this paper. This model has already been partly encompassed by other programs, however, these have concentrated solely on confirmatory Σ or subsets of μ. The algorithmic construction envisioned here is based on the much greater concerns of actual teaching and research. Since this is an ongoing research endeavor comments would be greatly appreciated.

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Technical Appendix: MOSAN Calculations

The method to be presented is a direct derivation of Jöreskog (1977) and Sörbom (1978). I will merely present some of the important features of the approach and the interested reader should go directly to these papers for a more comprehensive, detailed treatment.

Fitting Function

We can approach estimation and testing from two general directions. In each we wish to minimize the function value by some iterative sequence. These include the Maximum-Likelihood function.

1) $$f^{(g)}_{ML} = \ln|\Sigma^{(g)}| + \mathrm{tr}\ (\Sigma^{(g)-1}\ T^{(g)})$$

and the Weighted Least Squares function

2) $$f^{(g)}_{LS} = [\mathrm{tr}\ (T^{(g)} - \Sigma^{(g)})\ W^{(g)}]^2$$

In f_{LS} we note the presence of weighting matrix W. We can obtain serveral least squares forms using this W. For example, the Unweighted or Ordinary Least Squares (OLS) estimates may be obtained by setting $W=I$. The properties of OLS estimators are well known in many cases. By setting $W=S^{-1}$ we can obtain the Generalized Least Squares (GLS) estimators. Under several distributional conditions we may obtain global asympotic χ^2 goodness-of-fit test with GLS. Under multivariate normaility we can obtain these tests with ML estimators as well as assure asympotic efficiency in all estimates.

The global function value for G independent groups is then

3) $$F = \sum_{g=1}^{G} (n^{(g)}/2)\ f$$

where f is one of the previous functions. The $T^{(g)}$ matrix is defined in general as

4) $$T^{(g)} = n^{(g)-1} \sum_{\alpha=1}^{n^{(g)}} (Y^{(g)}_{\alpha} - \mu)(Y^{(g)}_{\alpha} - \mu)^{t}$$

MOSAN μ is defined as

5) $$\mu^{(g)} = \theta^{(g)}\ \Omega^{(g)-t}\ \Lambda^{(g)t}$$

and can be substituted into Equation 4.

First Order Derivatives

In this section we will implicitly define the g superscript. We need to calculate derivatives for all parameter matrices as follows

6) $\partial F/\partial \Lambda = 2n\{[W(\Sigma - T)W \Lambda \Omega^{-1} \Phi] - Q\}$

7) $\partial F/\partial \Omega = 2n\{-\Omega^{-t} \Lambda^{t}[W(\Sigma - T) W \Lambda \Omega^{-1} \Phi \Omega^{-1}] - Q\}$

8) $\partial F/\partial \Phi = \Omega^{-t} \Lambda^{t} \Sigma \Lambda \Omega^{-1}$

9) $\partial F/\partial \theta = n \Omega^{-t} \Lambda^{t} W(\Lambda \Omega^{-1} \theta - \overline{Y})$

where
10) $Q = W[(\overline{Y} - \Lambda \Omega^{-1} \theta) \theta^{t}]$

and
11) $W = \Sigma^{-1}$ for ML

$W = S^{-1}$ for GLS

$W = I$ for OLS

All second derivatives, including free, fixed, and constrained "to be equal" parameters fall out of Jöreskog's (1977) general mode. McDonald (1978) discusses how additional constraints "to be equal to a function of other parameters" may be added to any algorithm.

Calculation

MOSAN may be calculated in Σ form using the LISREL-IV (Jöreskog and Sörbom, 1978) or COSAN (McDonald, 1978) program. A limited form of μ and Σ may be done in the COFAMM (Sörbom and Jöreskog, 1976) program. While LISREL-IV and COFAMM calculate only ML estimators using a modified Davidon-Fletcher-Powell routine COSAN (A), using a quasi-Newton method, and COSAN (B), using a conjugate directions method, calculates OLS, GLS, and ML estimators. As mentioned in the text, the full MOSAN program is currently being developed to handle all of these ideas.

THE DEMISE OF THE PROGRAMMER

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ABSTRACT - - The author describes some of the difficulties inherent in Computer-Based Education (CBE) programming with respect to the use of programming languages. He then catalogues some existing courseware-creation tools which promise to change the role of the CBE programmer significantly in the near future.

We are all well acquainted with the vision of Programmer as emergency paramedic. How long has it been, after all, since you watched the team of crack systems programmers huddled around the supercomputer console trying to resuscitate their patient ? And why is it that we talk about "killing" the computer ? The Programmer is truly one of the Romantic roles of today.

The trouble with such images, amusing as they may be, is that in our heroic mood we tend to forget that the programmers are huddled around the console because one of their number MADE AN ERROR in programming. Somehow the complexity of the original problem, the solution (or the program which represents the solution at any rate), and the feeble tools and intellect we bring to bear on the solution have caught up with us.

It is clear that although programming as an art has been with us for many years, steps toward a science of software engineering (something which would help us deal with complexities) have been taken only recently.[1] We've been so busy just doing the requisite amount of programming that we haven't had time to really speculate about the origins of our travail. However, interest is more obvious lately. Backus[2] points out the source of our problems, saying "in its simplest form the von Neumann computer has three parts: a central processing unit (or CPU), a store, and a connecting tube that can transmit a single word between the CPU and the store (and send an address to the store)... the von Neumann bottleneck. The task of a program is to change the contents of the store in some major way; when one considers that this task must be accomplished entirely by pumping single words back and forth through the von Neumann bottleneck, the reason for its name becomes clear."

Just as in other areas, our Computer-Based Education (CBE) languages have become more complex (in Backus' words "more obese"), but have not broken clear of the organization of the von Neumann machine itself. They simply provide a slightly more abstract method of accomplishing this Herculean task.

To illustrate the complexity of the CBE task, let us step back a moment and examine what we're really trying to do in CBE. Heuston,[3] in a paper which interrelates the aspects of a number of educational media, describes four central educational problems faced by teachers. These are

1) Presentation of accurate information,
2) Giving the student adequate trials, with feedback,
3) Providing motivation and encouragement,
4) Assimilating or replicating educational strategies.

The technology of the book (printing press) effectively took over item 1, presentation of information. But, even today, items 2, 3 and 4 are almost the exclusive province of the teacher. With the advent of the videodisk, and Computer-Based Education, the teacher may receive help in all four areas. CBE handles trials with feedback many times better than the teacher could in a crowded class. Motivation and encouragement are aided by videodisk motion sequences, and by the "addictive" nature of CBE materials. But, it is item four, replication, upon which I wish to concentrate.

Ideally, the computer allows us to faithfully replicate an educational strategy, regardless of its complexity, provided that it can be represented (carried out) on the computer. In practice, however, the most difficult task we face is the description of the process we wish to carry out, and the representation of this process in terms the computer can execute.

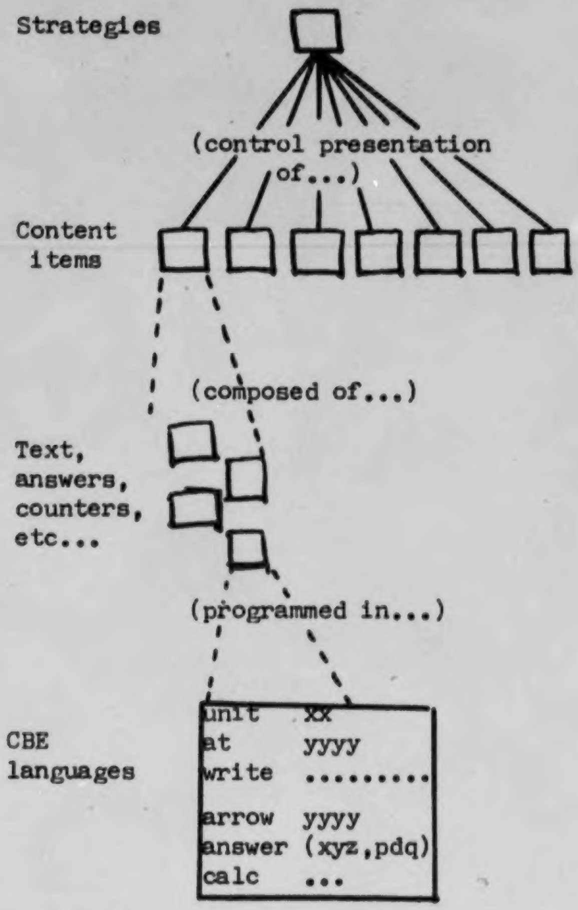
Though we have all done at least part of this already, let's examine the whole process to get a better feel for its complexity. The author of a CBE unit generally begins by examining the tasks s/he expects students to be able to complete following a course of instruction and formulating a (heirarchy) of educational objectives. The author then selects specific objectives which can be addressed by CBE modules (and others which require other media). These are broken down and problem types are selected to build toward mastery of each objective. Often the objectives are bundled into larger groups, and this bundling may change as the author gets farther and farther into the writing of actual problems and discovers skills which build upon other skills addressed by related objectives. Though I have used the word "heirarchy", actual structures may be much more complex, and relationships not necessarily unidirectional. In the well-organized courseware shop these structures are fairly complete before any programming begins.

In some instructional areas, such as mathematics, it may be possible to eliminate some of the problem-generation time by creating rules for elements to be plugged into a problem format one at a time. The programming task in such cases seems more straightforward. But, in most verbal topics, it is much more complex. Strategies must be selected for each of the objectives (ranging from drill to inquiry, in traditional CBE terms), and content must then be prepared to fit these instructional modes.

Before the advent of TICCIT[4], little thought had been given to how the computer itself might augment the creation of structures, strategies for learning, and content. With TICCIT a structure was created into which the authoring team inserted content. The learning strategy was not predefined, but was controlled by the student, who could move around within the predefined structures. The whole design provided a system which had characteristics which could be predicted by author and by student (vs. the unpredictable nature of all other CBE systems known to this author). Why have such systems-engineering concepts been adopted so slowly ?

It's partially because we're all too busy fighting the von Neumann bottleneck to be able to address the larger structures we really ought to be addressing. Look at what faces us - - suppose a system of courseware modules is being designed which contains 75 to 100 problem types, related to 25 different objectives. Drill items for each of these problem types would be combined under computer control, and the computer would present problems until the appropriate performance levels were reached for each objective. In a more complex presentational strategy, items corresponding to two or three objectives might be mixed together at the same time.

In a traditional CBE shop these drill items would be constructed by hand once the structure and content were laid out by an authoring team. Instructional programmers would then be responsible for following the documented problem types and creating programming-language code. To keep track of students' successes and mistakes a series of counters in memory would be used. These would be correlated with objectives, and perhaps with cognitive errors the student might be expected to make. Such data must be initialized at lesson's start, and saved upon termination, to create a student database. All of this multilayered structure is programmed by hand, and by programmers with varying expertise.


Strategies
(control presentation of...)
Content items
(composed of...)
Text, answers, counters, etc...
(programmed in...)
CBE languages
unit xx
at yyyy
write ....
arrow yyyy
answer (xyz,pdq)
calc ...

This amount of structure might be tolerable if a program could spring full grown from its author's head. In the real world this is too much to hope for. Modifications are constantly being made to both strategies and content. New items are added, and old ones deleted or replaced. Honest mistakes (typographical errors) are made. A programmer misplaces a single number and suddenly an item increments a counter for the wrong objective. The desired representation of the author's idea begins to diverge from the programmed representation of that idea and (horrors!) from the documentation. The author cannot understand the difficulties in execution, since they are the province of the programmer (who can't necessarily understand them either), and the programmer has great difficulty relating the performance of individual computer-language statements to the overall educational objectives.

Control can be maintained over programs of this complexity only through the strictest control of the authoring, updating and maintenance processes. This must be done at the highest level, and it is the thesis of this author that computerized tools are now available which make much of the role of the programmer in this schema almost obsolete. Instead, the role most needed is that of what we shall call an instructional packager.

Automated item creation

The first of the tools which will lead to the modification of the programmer's role has been available for a number of years. Using "automated" item-creation schemes, the packager (or the author) can select from a library of templates or formats, inserting his or her content material. The Coursewriter MACRO facility was the first of these methods, though it was relatively inflexible. Later the creators of PLANIT recognized the need for a set of fixed frame types.

The PLANIT frame types, of course, are interactive, unlike the MACRO facilities. An interactive format (like Hewlett-Packard's IDF, for example) allows the author to specify modifications as the item is created. It may permit a variable number of anticipated answer phrases, or the combination of various types of answer-checking, within a single frame type. It is common to allow the specification of branches as well, thus facilitating the creation of branching tutorials.

But the most oft-voiced criticism of such systems is that they leave little leeway for programmers who need to add special touches. The new genration of authoring systems, beginning with the Courseware Design System[5], goes far beyond the fixed format, permitting authors to create their own interactive templates, and even to modify the author-interaction itself. Graphics will be central to the new systems, and we can expect direct digitizing inputs from inexpensive bitpads, rather than the cumbersome and unnatural "cursor" graphic inputs used on current CBE systems.

Because automated item creation takes the programmer out of the loop entirely for most items, it eliminates a major source of programming bugs (that is, misconceptions and typographical errors) and directly cuts programming time by at least 50 %.

Structures

As the complexity of the educational task increases, we will call more and more upon the courseware-creation systems on the computer to aid our understanding of the structures we are creating. The creation of "maps" for courseware modules (or heirarchies) will be done by the computer as the objectives are entered into memory. We can also expect this task to be highly dependent upon graphics, and upon written (drawn) inputs rather than "cursor" systems. The diversity of structures these sytems can handle should be quite impressive. We have done some work at WICAT in which the TICCIT structure of RULE/EXAMPLE/PRACTICE has been modified and inserted on a text-only computer system, but combined with a "script" which can provide a more standard tutorial interaction for those who wish to be directed through the content by the computer rather than directing their own path.

As authors and packagers update the structure and the content of a courseware module, the authoring systems will record these changes and make them available to authors, to courseware managers, and to students involved in pilot testing. Because updating of the map and structure information is done by the computer, another source of error is eliminated.

Performance data

During pilot testing of courseware, data on student performance can be collected easily on most authoring systems. But, on target delivery systems, especially if microcomputers are used, the code to do data collection must be hand-written into the end-user program. Automated lesson-creation systems can just as easily add code for response recording as they can any other type of data collection code.

Translation

And at the bottom line, we must share courseware in order to make its creation economically viable. Specific translator programs for CBE languages have been in use for a number of years. In fact, a number of CBE languages are first translated into a general purpose programming language before being executed. But, the use of rule-driven translators, with translation rulesets created for the most common and popular target systems, means that large volumes of courseware could quickly be converted for any new microcomputer system. Directly linked with the idea of translation is the storage of CBE programs in a canonical form which could be quickly translated for target delivery systems. In this era of rapidly changing hardware and software systems, this may well be the only economical way to create courseware.

Scenario

Although we have now described a fairly large array of courseware creation tools, it would be foolish to speculate on the *most* likely authoring systems of the future. It is clear that the potential exists for microcomputer authoring systems which would feed larger delivery systems, as well as for supercomputer authoring systems to drive small standalone clusters.

But, it is equally clear that the role of the programmer in CBE courseware development will change. The programmer will slide on the scale, away from "system guru" toward the "author" end of the scale. CBE Packagers will be responsible for understanding the structure of the modules they put on the computer, and for checking those structures once they're "on" the computer. As graphics become more important, and input becomes easier, many packagers will find their artistic skills being utilized. The opinions of a packager on wording of text, and on anticipated answers, will be heeded. Difficulties with strategies will be worked out by the packager in conjunction with the authoring team. Bugs in *programs* will be replaced by bugs in *curriculum*, which the CBE packager will have increasing responsibility for.

In short, the job may appeal to, and may require, a different type of individual. I'm confident that it's the type of individual we would all like to be - - concerned with efficient, individualized, *motivating* instruction.

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Effect of Criterion Manipulation on Time Taken in Self-paced Learning

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In the past two decades, a variety of alternative instructional approaches have been used in college courses. Kulik and Jaksa (1977) reviewed 103 studies comparing alternative approaces including Keller's Personalized System of Instruction (PSI), other behavioral systems, programmed instruction, computer-assisted instruction, the Audio-Tutorial Approach, and instructional television with the conventional lecture-style college teaching. Of the alternatives they studied, the PSI approach and those based upon the experimental analysis of behavior almost consistently set the occasion for greater student achievement when compared to conventional college teaching methods.

In traditional college courses utilizing a few scheduled testing dates such as midterm and final examinations (i.e., a fixed-interval schedule of reinforcement), students typically procrastinate until just before the deadlines and then must learn a large amount of the course content in a relatively short time. This infrequent testing with no additional opportunities to meet mastery criteria appears to be one of the major reasons why students enrolled in traditional courses usually do not achieve as well as those students in courses utilizing frequent tests over small amounts of material with opportunities to retake alternate forms of the tests (Caldwell, Bissonettee, Klishis, Ripley, Farudi, Hochstetter, & Radiker, 1978; Cole, Martin, & Vincent, 1975; Williams & Lawrence, 1974).

Many college courses are now utilizing PSI and variations of the PSI theme (Keller, 1974b), hereafter referred to as "behavioral instruction." One of the features of some behavioral instruction courses has been self-paced learning (Atkias & Lockhart, 1976; Cole et al., 1975; Keller, 1968). Self-pacing allows students to work at their own rates to complete course requirements. Holding achievement constant and allowing time to vary permits both those students who exhibit higher and lower rates of learning, as compared to the average student, to master the course content without being held back or pushed ahead.

Although students generally view self-paced courses as more desirable than those where requirements are scheduled by the instructor, there are important concerns to be addressed when students are allowed to self-pace. Sherman (1974) notes that:

> At the outset, PSI was a plan to base educational advancement on accomplishment rather than on the clock and calendar. Self-pacing was intended to be exactly that, hardly hampered by boundaries called "courses" and certainly not prohibited by time restraints called semesters." Few, if any, PSI courses have followed that concept. Most should be called "self-paced up to a point," that point being determined by the registrar, dean, or whomever we credit with setting the university calendar (p. 64).

Thus, college courses that feature a self-paced curriculum are usually restricted by administrative requirements that grades be submitted at the end of the semester.

Even though Robin's (1976) review of the literature almost consistently supports the superiority of behavioral instruction over traditional instruction in such areas as academic achievement, long-term retention of knowledge, and students' attitudes toward their coursework, there are problems other than administrative that often accompany behavioral instruction. Keller (1974a) describes three types of proctors: testing, grading, and study-hall. The former is not involved with instruction but tests students and keeps a record of student progress. The latter two, however, serve as links between the instructor and textbook, respectively, and they also serve instructional purposes. Because they are involved with helping students master the course content, they must be carefully selected, trained, and their performance monitored on a regular basis (Semb, 1974; Weaver & Miller, 1975). However, in spite of careful proctor selection and training, there is still the possibility of variable proctor behavior when evaluating student performance (Quigley, 1975). Proctors have also had difficulties arranging their schedules to accomodate the greater number of testing sessions that usually occur near the end of grading periods (Sutterer & Holloway, 1975). Although students often give positive reports about interacting with their proctors (Rosati, 1975), instructors must address the previous factors when considering the implementation of a course utilizing proctors.

Another factor to consider is the often higher withdrawal rates for students in courses that feature self-pacing (Semb, Conyers, Spencer, & Sosa, 1975). The problem of student procrastination in self-paced courses (Semb et al., 1975) may be one of the reasons why students tend to withdraw at a higher rate than in those courses that use instructor-paced schedules or a combination of instructor and student schedules. Although self-pacing is one of the elements of the Keller Plan (Keller, 1974a), student achievement appears to be as good or better in courses that do not rely exclusively upon self-pacing (Fernald, Chiseri, Lawson, Scroggs, & Riddell, 1975; Morris, Surber, & Bijou, 1978). Achievement remained at high levels and the student's rate of learning increased in courses where target dates were given for assignments (Miller, Weaver, & Semb, 1974) and when bonus points could be earned for completing work during specified time periods (Bufford, 1976).

In addition to instructor-paced or a combination of student and instructor-paced schedules, modern computer technology has been used to solve some of the problems associated with behavioral instruction. In courses providing for mastery learning, multiple copies of quizzes must be available for students who need to take more than one form of a quiz to achieve the specified mastery criterion. Once programmed, computers can randomly select questions from a large item pool (Mack & McCaffer, 1978). This procedure permits students to take many quizzes and have them scored without corresponding increases in instructor and proctor time involved in monitoring this additional responsibility. All questions can be objectively scored and the program can safeguard the integrity of the item pool.

Another procedure that facilitates mastery learning is the provision for immediate feedback (Block, 1971). Evans & Surkan (1977) used computer-assisted testing to allow students to earn partial credit for a question by repeating the question until they identified the correct response, and earning points based on the number of repetitions. After correct responses were identified, feedback frames were presented that reinforced students for correct responses in addition to describing why other responses were incorrect.

Journals (e.g., *Educational Technology* and the *Journal of Computer-Based Instruction*) have reported the increasing number of ways computer-assisted instruction and/or testing has been used to facilitate mastery learning and behavioral instruction principles. The purpose of this study was to examine the effects of mastery criteria manipulation on student performance and pacing in a college course using interactive testing with a microcomputer.

METHOD

Subjects

Students were enrolled in an undergraduate educational psychology class which was part of an introductory teacher education course sequence at a private, liberal arts college. The entire class from each of the Spring semesters 1976, 1977, and 1978 comprised the two control groups, and experimental group, respectively, and numbered 39, 38, and 32 students. Composite ACT socres were available for 39, 35, and 26 students from the three groups, and yielded mean scores of 21.7, 22.3, and 21.8 --not significantly different.

A unique feature of the course was its self-paced format using Biehler (1974) materials programmed in APL for interactive testing out-of-class on an IBM 5100 portable computer. All students were required to attend a class session one day a week, serve as a teacher's aide in an elementary school one day a week, and make appointments for five course examinations which required mastery levels of 90, 80, 70, and 60 percent for course grades of

A, B, C, and D. Each examination consisted of 15 randomly selected questions from one of five item pools. Feedback frames were presented after a correct answer was chosen, and if the students did not like their level of performance exhibited on the total test, they could consult with the instructor, study some more, and retake the test up to three times. The final grade was determined by identifying the highest test grade across all five tests. To get an "A" for the course, sutdents had to have an ultimate "A" on all five course examinations; the same was true for lesser course grades.

Treatment

The experimental group differed from the controls in that the percentage correct criterion for the various test grades was manipulated. The requirement for an "A" was lowered by 5% if the tests were taken one week prior to the domain of knowledge being covered in class sessions, and raised 5% for all grades if taken three or more weeks after the class had finished the topic.
Once the five tests were taken at a criterion acceptable to the student, class attendance was no longer required. Since the usual instructor was on sabbatical during the semester the experimental group was enrolled in educational psychology, another instructor from the education department taught this class. However, the course materials and class format (primarily discussion over student questions) remained constant.

Dependent Variables

The effects of the treatment were analyzed over data from the following five measures: (a) Days since the beginning of the semester the students took their first attempt on each of the five course examinations (TDAYS); (b) Days since the beginning of the semester that the students got their highest score on the five examinations (HDAYS); (c) The number of attempts the students made on each of the five examinations (TRIALS); (d) Raw scores on the highest trial of each of the five examinations (HRAW); and (e) Final grades in the course (GRADES). The HRAW scores were partial scores, allowed by an answer-until-correct procedure on each test item and scoring the four-option multiple-choice questions 3-2-1-0 depending on the number of choices required to get a correct answer. Thus, a 15 question test had a maximum of 45 raw score points available. The TDAYS and HDAYS scores included weekends and holidays, considering all days since the semester began in January until the particular examination attempt was made. Letter GRADES were converted to the numerical 4 point system.

RESULTS

Table 1 presents the group mean scores on each of the measures. Univariate analysis of variance revealed that the experimental group completed each of the five course examinations in significantly fewer days than the control groups in both TDAYS and HDAYS. With the possible exception of trials on test 1, there were no other notable differences among the groups in TRIALS, HRAW, or GRADES. The mean standard deviations across the five examinations were 17.9 for HDAYS and 13.5 for TDAYS.

DISCUSSION

The results show that manipulation of criteria for letter grades by the instructor is an effective method of setting the occasion for students to complete course requirements earlier in the semester than when there were no such external incentives. This conclusion holds for both days until the examination was first attempted (TDAYS) and days until the students achieved their personal criterion score (HDAYS). Such manipulation results in an increase in learning efficiency, because the earlier completion of the indices of progress in the course -- the five examinations -- was not at the expense of the standards for performance. These findings are consistent with those of Morris et al. (1978) and Semb et al. (1975) who also found no loss in student performance when external incentives were used to remediate the problem of student procrastination in "self-paced" courses of study.

The problems associated with the use of proctors in self-paced learning can be assuaged through use of microcomputer-administered interactive testing. It avoids the need for training and monitoring proctor performance. It is a tireless worker that maintains its standards throughout the semester, particularly near the end of the course when proctors often must be more concerned with completing their own requirements in other courses.

Table 1
Mean Scores of three groups on Five Dependent Variables

Measure		Group			F
		Control 1976	Control 1977	Experimental 1978	(df = 2/106)
TDAYS	1	20.26	21.39	11.69	13.12***
	2	37.62	40.50	27.66	7.74***
	3	63.26	61.76	45.22	11.34***
	4	82.44	85.42	68.06	11.44***
	5	98.64	98.79	91.88	3.24*
HDAYS	1	25.33	35.08	18.32	6.39**
	2	43.08	50.24	34.29	5.15**
	3	71.15	70.03	50.10	10.55***
	4	89.05	91.11	74.32	9.24***
	5	101.03	99.87	93.23	3.73*
TRIALS	1	1.87	2.47	2.16	5.28**
	2	1.92	2.08	1.97	.26
	3	2.31	2.29	2.09	.61
	4	2.13	2.37	2.19	.47
	5	1.59	1.47	1.56	.26
HRAW	1	40.82	40.11	40.44	.53
	2	40.82	40.00	40.38	.75
	3	39.64	39.29	39.91	.33
	4	39.08	39.03	40.13	1.23
	5	39.26	39.42	39.31	.02
GRADES		3.26	3.21	3.25	.04

* $p < .05$
** $p < .01$
*** $p < .001$

In addition, the use of computer-administered interactive testing provides an escape from the administrative requirement of enslaving learners to "clock and calendar,' mentioned by Sherman (1974). There is little evidence to suggest that the optimum time allowed for learning a three semester-hour course should span approximately 110 days. Although the semester has been the traditional time period during which students are held accountable for learning and is administratively convenient, the standard deviations reported in the present study suggest that there is great variance in the time required by individual learners to master course material. Indeed, some of the students in the control groups reported lowering the level of course mastery to which they had aspired (A, B, C grades) because of the requirement by the registrar to submit a grade at the end of the semester. In effect, since the time for learning was running out, they elected to settle for a lower grade rather than an "F."

But *should* human beings be put under pressure to settle for half-learning a subject in order to meet arbitrary deadlines? The technology demonstrated in this study provides options heretofore not readily available to administrators of schools to provide the time flexibility necessary to insist on mastery learning for all students.

Teachers and administrators are faced with a dilemma. External manipulation of incentives seems to cause students to progress through a course faster than they would if they were allowed to be truly self-paced. But even with these incentives, there are some who cannot master the material in the 110 days allowed in the semester, and they may settle for lower levels of performance. This is further complicated by the locus of control studies which show that those who are more internally motivated show greater achievement in school-related activities (Crandall, Katkovsky, & Crandall, 1965) but that such a relationship could not be found with time taken to complete a course (Johnson & Croft, 1975).

While it was not specifically proven in the present study, the investigators suggest that internal control of student learning is more desirable than external control.

However, when it appears that students do not have the necessary internal controls to budget their time to master course content, external controls then become necessary. Methods need to be developed to identify those students who do not need external prompts to complete course requirements and further study must address the question of how to design an instructional environment that sets the occasion for developing internal control. The flexibility allowed by microcomputer technology sets the stage for such development.

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DESIGN AND IMPLEMENTATION OF A SHARED CAI CONTROL PROGRAM ON A MINI-BASED SYSTEM

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This paper discusses the design and implementation of a shared CAI control program which could be used by many minicomputer-based CAI systems.

This Shared Control Program (SCP) was implemented in BASIC-PLUS on a PDP-11/45 running under the RSTS operation system. In its simplest application, the author need only supply the text of the lesson to the SCP which will handle sequence control, framing, and intermediate questioning in a very efficient manner. A pre-test and/or post-test can be linked to the SCP in such a way that transition from one to the other is transparent to the user. By forcing break points in the body of a lesson, the author can easily incorporate any audio-visual aids into the lesson.

BACKGROUND

From the first minicomputer introduced in 1963 to present-day microcomputers, the progress in electronics technology has been steady and sophisticated providing better performance and lower price. However, software technology for minicomputers was lagging behind hardware technology throughout the 1960's and part of the 1970's. This has been corrected at the present time. Sophisticated software packages have been validated from both the economic and feasibility point of view and have started to appear on the market in abundance for minicomputer systems[1]. There is, however, a lack of good educational software packages to help in the preparation of courseware for the mini-CAI systems.

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For maxi-systems, CAI courses have been traditionally authored and maintained by programmers who were familiar with the hardware and software used to implement the lessons. Unfortunately, programmers seldom have the background needed to present thorough CAI lessons for all the disciplines that use CAI today. At the other end of the spectrum is the specialist with the background needed to write a good course but who lacks the programming skills needed to make it work effectively.

These two examples are perhaps extreme, but they do point a finger to the problem: how to put a good CAI lesson together with a good program to control the flow of the lesson. The specialist and programmer mentioned above could certainly work together to author a thorough and efficient CAI course. This solution, however, uses too much manpower to develop a CAI course that is of a "one shot" rigid design. In addition to this problem is the classic problem of communication between the two people. To move such a lesson to a different system could result in a repeat of a major portion of the development process. For maxi-systems, this cost may be economically sound, but the restrained environment of typical mini-systems will seldom justify such expenses.

Quite often when a nonprogrammer attempts to write a CAI course, the course itself becomes secondary to the mechanics of writing a control program which is sensitive to the needs of the typical users. Because of this overemphasis on the control program, testing before and after the course (pre-test and post-test) is rarely incorporated into the course. Testing is a very important part of CAI courseware and cannot be cast aside so readily.

With this brief background, a list of "wants" is fairly easy to enumerate. A method for developing CAI courseware is needed that will:

(1) free the author from the need to learn a programming language.

(2) free the programmer from repetitive software development.

(3) allow transfer of courseware from one system to another without major difficulties.

In brief, the author and the programmer must be free to concentrate on his own specialty—the author with writing a good CAI course, and the programmer with maintaining the software that presents the course. Many maxi-systems have software allowing the nonprogrammer to author a CAI course; but only recently has such software been economically suited for mini-systems[1].

A SOLUTION

At California Polytechnic State University (Cal Poly), San Luis Obispo, a possible avenue of attack has been developed. A Shared Control Program (SCP) has been designed and implemented to work smoothly from both the user's and author's viewpoint. The SCP allows anyone to write a linear CAI course without requiring him to spend hours mastering a programming language. Those wishing to spend time programming can now spend it more wisely on designing a good pre-test and post-test to be incorporated with the lesson.

The biggest blessing to the author is that the SCP is maintained separately from the actual courseware. In fact, all authors share one SCP; it is not duplicated for each lesson (this is a great relief to the maintenance programmer). The SCP is also very sensitive to the user's environment and interfaces quite smoothly with his needs.

Briefly, it works like this. The author writes an entry program that calls the SCP and passes to it the required lesson parameters. One of these parameters is the name of a file containing the text of the lesson. The lesson is not hard coded, but rather an easy-to-edit text file. The SCP then presents the lesson to the user in a smooth and well paced manner. When the lesson is finished, the SCP transfers control to an exit program written by the author of the CAI course.

THE PROGRAM

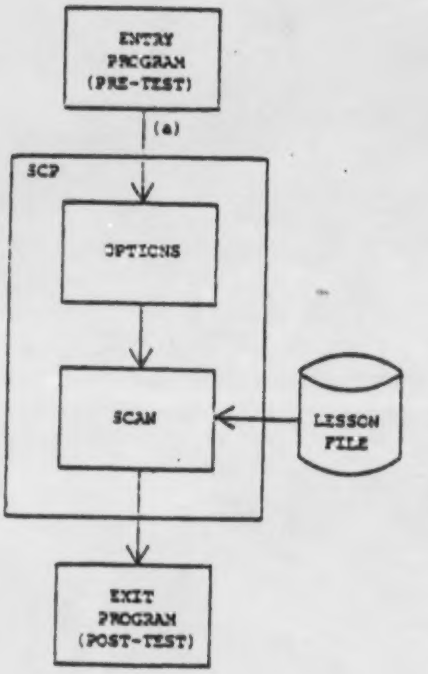
The SCP, written in BASIC-PLUS, is a fairly simple program centering around two main routines. The first routine (SCAN) goes sequentially through the author-supplied text file and presents the lesson for viewing on a CRT. The second routine (OPTIONS) is responsible for handling a menu of options available to the viewer of the lesson.

The SCAN routine includes a check for positional parameters (commands) in the lesson file which delimit lessons and help control lesson flow. There are also commands to guide the SCP through a clean presentation of any intermediate questions in the lesson. Whenever the SCAN routine encounters an imbedded command, it simply goes to a subroutine which handles the activity related to that command. These commands are no real burden to the author since they are few in number and concisely defined.

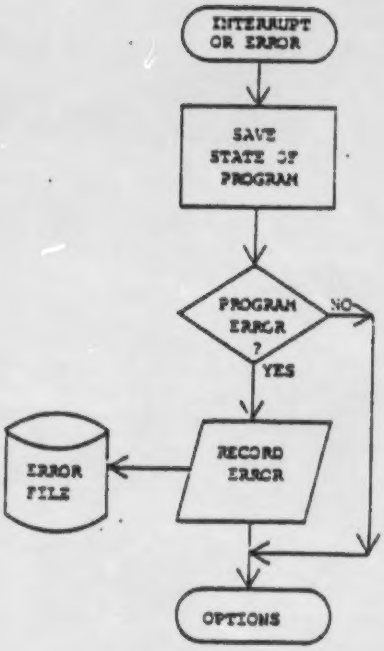
The OPTIONS routine is invoked initially by the authors' entry program (possibly a pre-test) to provide the end user with a menu of available options. These options allow the user to view an instruction file, browse the index of lessons or select a specific lesson for viewing. The OPTIONS routine can be invoked by the user at any time by depressing the interrupt key. After an interrupt, one of the user's options is to continue the lesson exactly where he left off. The authors' only responsibility is to define the lesson titles for the index by passing them from the entry program.

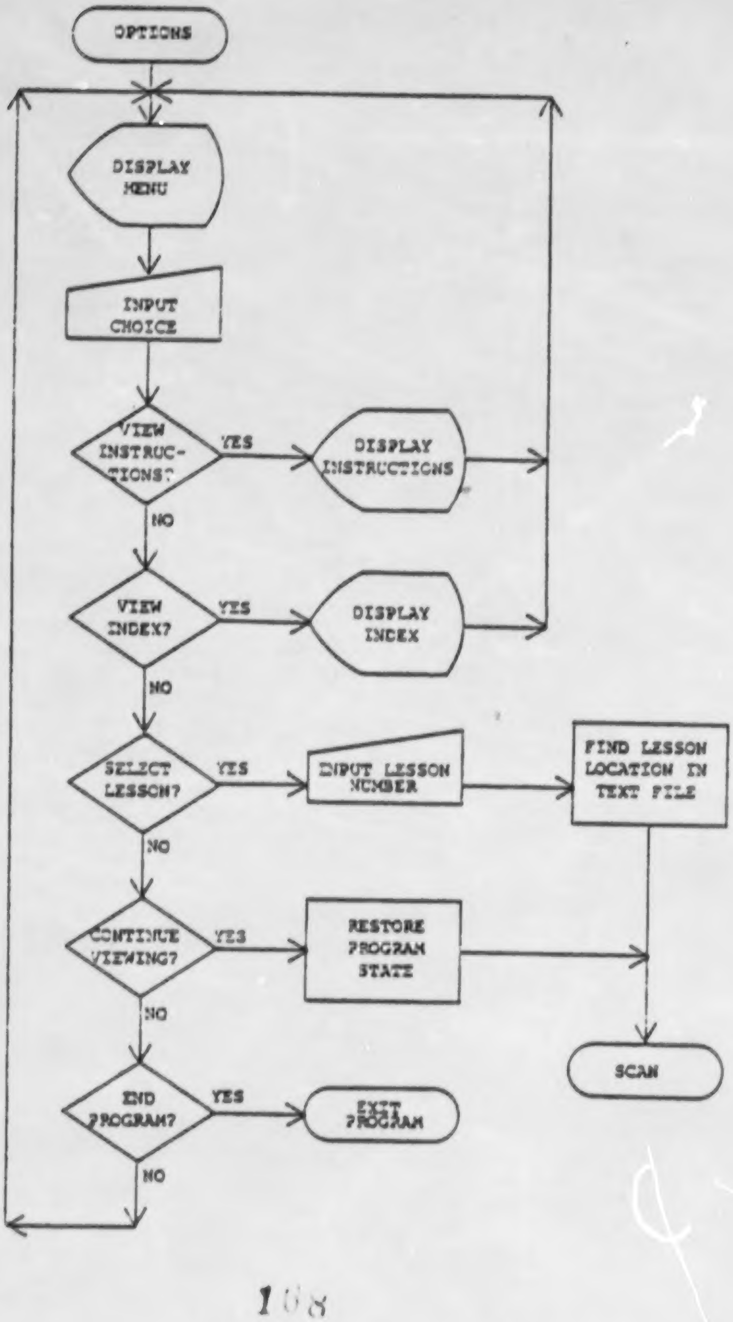
When the lesson is completed or when the user thinks he is ready, the SCP passes control to an exit program, which again could be a post-test. The gross flowcharts below illustrate the general program flow. Note that any program errors are recorded on an error file for later viewing by the maintenance programmer. Like the SCP, there is only one error file which is shared by all users of the SCP.

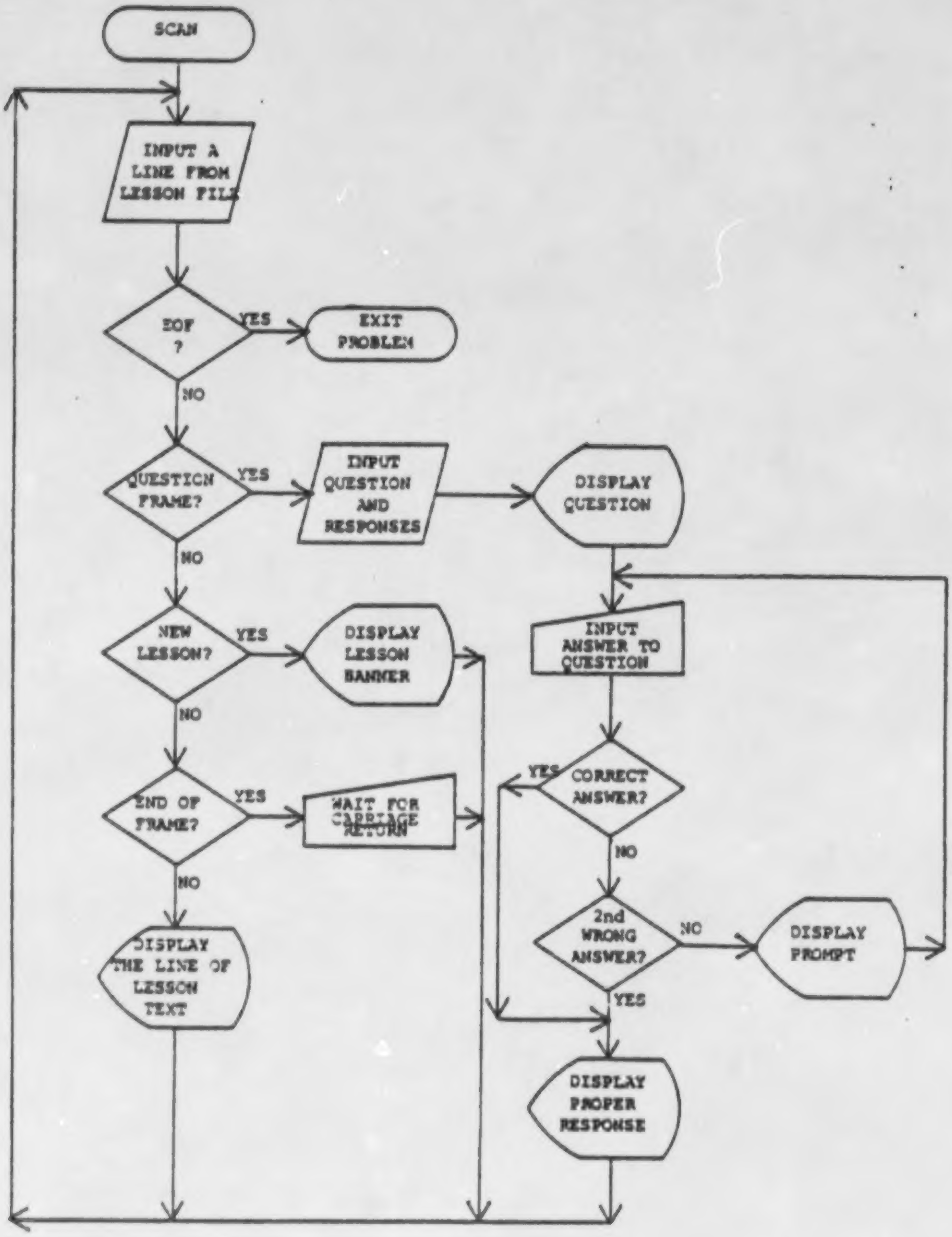
This is by no means an exhaustive description of how the program works. Such a venture would cast too much attention on the small details of the program. Emphasis should be placed on the fact that the actual lesson is not a program, but rather a text file which is passed as data to a general purpose control program.


ENTRY PROGRAM (PRE-TEST)
(a)
SCP
OPTIONS
SCAN
LESSON FILE
EXIT PROGRAM (POST-TEST)

(a) The entry program passes the name of the lesson file to the SCP.


INTERRUPT OR ERROR
SAVE STATE OF PROGRAM
PROGRAM ERROR ?
NO
YES
RECORD ERROR
ERROR FILE
OPTIONS


OPTIONS
DISPLAY MENU
INPUT CHOICE
VIEW INSTRUCTIONS?
YES
DISPLAY INSTRUCTIONS
NO
VIEW INDEX?
YES
DISPLAY INDEX
NO
SELECT LESSON?
YES
INPUT LESSON NUMBER
FIND LESSON LOCATION IN TEXT FILE
NO
CONTINUE VIEWING?
YES
RESTORE PROGRAM STATE
SCAN
NO
END PROGRAM?
YES
EXIT PROGRAM
NO


SCAN
INPUT A LINE FROM LESSON FILE
EOF ?
YES
EXIT PROBLEM
NO
QUESTION FRAME?
YES
INPUT QUESTION AND RESPONSES
DISPLAY QUESTION
NO
NEW LESSON?
YES
DISPLAY LESSON BANNER
INPUT ANSWER TO QUESTION
NO
END OF FRAME?
YES
WAIT FOR CARRIAGE RETURN
YES
CORRECT ANSWER?
NO
NO
DISPLAY THE LINE OF LESSON TEXT
2nd WRONG ANSWER?
NO
DISPLAY PROMPT
YES
DISPLAY PROPER RESPONSE

HOW TO USE THE SCP

The entry and exit programs could be simple routines to fit the minimum requirements of the SCP. However, the author can take advantage of the opportunity to give the user a pre-test and post-test, if so desired. These tests would have to be programmed by the author, but the lesson would just be a text file which the SCP will pick up as data.

The SCP handles lesson control, framing and questioning by interpreting a series of simple control statements placed in the lesson text by the author. Below is a list of the control statements used by the SCP at Cal Poly.

/LESSON/*nn*	Marks the beginning of lesson *nn*; *nn* is a lesson number between 1 and 99.
/ENDFRM/	Marks the end of a frame of text. The SCP will halt until the user depresses the carriage return to continue. Through careful planning and use of this command, one can incorporate audio-visual aids into the lesson without any trouble.
/QSTFRM/	Marks the beginning of a question frame (detailed below).
/ENDQST/	Marks the end of a question.

Following a /QSTFRM/ statement, the author is required to provide the following:

Line 1	Correct answer, question number.
Line 2	Message to print if question is answered incorrectly twice.
Line 3	Response if answer was 'A'.
Line 4	Response if answer was 'B'.
Line 5	Response if answer was 'C'.
Line 6	Response if answer was 'D'.

Following these six lines, the author enters the body of the question followed by the /ENDQST/ statement. An example follows from a hypothetical skydiving course:

```
/QSTFRM/
A,5
SORRY.....THE CORRECT ANSWER WAS A.
THAT'S RIGHT!
NO, YOU SHOULDN'T EVEN BE FLYING!
NO, YOU MIGHT HAVE A FATAL ENCOUNTER WITH EARTH!
NO, THE CORRECT ANSWER IS GIVEN.
SKYDIVING IS DONE BEST
     (A)  ON A CLEAR, CALM DAY
     (B)  DURING A STORM
     (C)  AT NIGHT
     (D)  NONE OF THE ABOVE
/ENDQST/
```

The author must have an understanding of a text editor to build the text file for the CAI course, but this training is typically negligible compared to the learning of a programming language[2].

CONCLUSION

A shared CAI control program has been designed and implemented in BASIC-PLUS on a PDP 11/45 running under the RSTS operating system. This approach allows the mini-CAI systems to have one more software feature that was reserved for maxi-CAI systems. This trend will make it increasingly more attractive to create mini-CAI systems with highly reliable, secure and transferable software and courseware.

The natural extension of this concept is the microprocessor-based CAI systems. To use microprocessors as teaching tools has already been established[3]. These new tools need now the type of software support discussed in this paper.

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A MICRO-PROCESSOR BASED SYSTEM AS A CLASSROOM TEACHING TOOL

by

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In this paper two instructional strategies incorporating the Radio Shack TRS-80 microprocessor based computer system will be described. These strategies can be used in many subject areas besides those that will be described and can take advantage of hardware features found on virtually all of the low-priced microprocessor based systems now commercially available. In the first of the strategies to be described the TRS-80 is used to drive a 24" television monitor. Because of the availability of a 32-character output line, the computer output is readily visible to the students. Using this feature I have been able to develop computer-based excercises in which the computer (with the television monitor) functions as a dynamic blackboard. The computer is used to generate examples, step the students through the examples, end enhance classroom discussion. Used in this way the conventional classroom lecture has become far more exciting and more effective for the students and - I believe - has led to improved learning.

In the second of the instructional strategies to be described, the small, high speed printer available with the system is used to generate problem sets for the students. These are used both for reinforcement, i.e. homework, as well as for evaluation purposes. Using the random number generator implicit in all versions of BASIC, the computer generates unique problem sets. These problem sets can be conveniently duplicated for the entire class by creating a spirit master directly from the computer output. Alternativelt individualized problem sets can be generated for students having particular difficulty. We have even been able to personalize the problem sets by having the computer print the name of the student on his or her problem set. Because the computer is doing "all the work" we have been able to move towards criterion-referenced instruction. This has resulted in less pressure on the students and a decrease in cheating. Student motivation has increased and - we believe - so has the learning taking place.

At the "bottom line" of both of these instructional strategies which incorporate the use of the microprocessor based system is their cost-effectiveness. Compared to all of the other alternative hardware approaches, microprocessor based systems are the least expensive. Furthermore they permit us to do considerably more in terms of various instructional strategies. In fact I am now able to do things in the classroom that I was not able to do before - although I would have liked to - and even to do those things that I was doing before, but more effectively.

Hardware

Before describing the instructional strategies in detail, the hardware configuration shall be presented. As mentioned, the features available in the Radio Shack TRS-80 are available in both of the other popular home computer systems. These are the Commodore PET and the Apple II. What is important to note are the particular features which make possible the instructional strategies to be described. These features have not been conveniently available on conventional time-sharing systems. Interestingly in recent months in presenting these strategies to other teachers I have found them to be far more receptive to these strategies than to the strategies implicit in the use of time-shared terminals. (Is there a message here?)

The hardware configuration includes the following items and features:

a) a CPU including keyboard with 16K bytes of internal storage. I have been able to recommend as little as 4K bytes to schools since most of the computer programs we use to implement the strategies to be described do not require more than 4K.
b) convenient output to a television monitor. The Radio Shack TRS-80 uses a conventional DIN connector which is readily available at any electrical supply store. The Apple II also has a convenient connection. The PET's connection is a little more complicated. In addition the size of the output on the monitor must be readable some distance from the monitor. We have found that a 32-character output line, which is available on all three of the small home systems, is quite

adequate. The Digilog Telecomputer is the only time-sharing terminal that we know of that has a similar output capability. (Note: the DIGILOG costs in the neighborhood of $2000. This is more than the cost of the entire Radio Shack microprocessor based system.)

c) convenient medium of program storage. All of the home computer systems use conventional audio cassette technology for mass storage. This makes it very convenient to transfer programs between schools and between teachers. It is also psychologically satisfying to the neophyte computer person to have complete control over their programs. Also becoming available are minifloppy disk systems which can be used with the home computer systems. While the use of this technology is more expensive (it adds about $400 to the cost of the system), minifloppy disks have the advantage of greater speed and reliability while still retaining the use of a relatively inexpensive medium for program transfer (a minifloppy disk capable of storing 80 to 120 K bytes costs between $3 and $5).

d) high speed printer. All of the home computer systems mentioned support such printers as the new Centronics P-1. This printer in particular prints at 180 characters per second, prints both upper and lower case, as well as in several character sizes. It is quiet,too. Most important is that it only adds about $600 to the cost of the total system. Compare this to the popular DEC-Writer which only prints at 30 characters per second, does not have flexible character sizes, and costs itself in the neighborhood of $2000.

e) portability. All of the systems can be placed in their entirety on a cart and moved from classroom to classroom. All you need is an electrical outlet to operate the entire facility. Compare this to time-sharing terminals most of which can only be moved with difficulty and all of which must be connected to a telephone. Another expense.

f) ease of service. Any Radio Shack store will accept a TRS-80 for service. They in turn send it on to a local service center - their responsibility, not yours. PET advertises that their system can be serviced by any TV technician. Such is not the case with computer terminals, and certainly not the case with time-sharing computers.

g) finally, we have alluded to the low cost. A 16K CPU, plus monitor, cassette recorder, expander box, and printer is about $1900. The addition of the minifloppy disk brings the cost to $2300. The Apple II and the Commodore PET are competitive for the same features. THIS IS THE COST FOR THE COMPLETE SYSTEM!

Strategy 1 - The Computerized Blackboard

At the time that this is being written the author has used this strategy in two types of courses: courses in computer programming (FORTRAN and BASIC) and various levels of courses in mathematics. The author is also the coordinator of an experiment being conducted in five junior high schools within the Cleveland Board of Education where a number of teachers in several different subject matter areas are using this strategy.

The strategy can best be illustrated by citing an example. In a course in trigonometry taught by the author, amongst the objectives is the requirement that students be able to transform angles measured in degrees into angles measured in radians and vice versa. We are also interested that students be able to transform a very large angle (considerably larger than 360°) into the least positive angle coterminal with it (an angle less than 360°). Furthermore we would like the students to be able to convert the decimal portion of an angle into minutes and seconds and vice versa. We insist that our students use calculators in attaining these objectives, and we teach them the appropriate algorithms to use in problem solving.

For each type of problem mentioned above we have prepared a small computer program which generates a problem for the students and presents it on the screen of the television monitor. The students are then asked to solve the problem in class. After a few moments the computer "solves" the problem as well. On the screen the computer prints out not only the solution but also the results of each step of the algorithm. This permits the students to check their own work at each step of solving the problem. The instructor is able to discuss each step of the problem with the results obtained. The students are able to ask questions about each step of the problem. In general a framework for classroom discussion has been established. With a simple RUN command another problem can be presented and the students can again try to solve the problem. This process can be continued as long as the instructor deems it necessary. At some point we have even begun to challange the students by setting time deadlines and introducing a spirit of competition. Finally the same approach is used for administering a quiz. In essence we are using the computer and the television monitor as we would use the blackboard. Practically speaking we have found that using the computer in this way is much easier and much less time-consuming than is the use of the blackboard.

From a logistical point of view this strategy involves moving the hardware which includes the monitor and which sits on a cart to the classroom, plugging the computer and the tape recorder (for reading in the computer program from a cassette) into an electrical socket, reading in the program (about a half minute), and running the program.

The author has also used this approach in courses in computer programming (both FORTRAN and BASIC) which he has taught. While computer programming courses use computers implicitly, there is a need for better audio-visual aids which can be used in the classroom for presenting to the students the various commands and programming techniques. What better way to teach computer programming than by having the computer itself actually operate in the classroom with students being able to see commands entered and then executed.

For example, in teaching the concept of looping in BASIC,a small program is typed in which includes a simple loop which will print the looping index and its square.

```
100  FOR  I  = 1  TO  10
110  PRINT  I, I  2
120  NEXT  I
```

The program is run and students see the results. We then discuss what happens when the step size is changed. We type in

```
100  FOR  I  = 1 TO  10  STEP  2
```

and RUN, then we try

```
100  FOR  I  = 1  TO  10  STEP .5
```

and RUN then we try

```
100  FOR  I  = 10 TO  1   STEP -1
```

and RUN.

Seeing is believing. The large character size which is available permits this approach to be used in class. Because students can ask many questions and see the answers to those questions demonstrated immediately, both motivation and learning have improved. Virtually all facets of the programming course can be approached in this way.

Strategy 2 - The Computerized Problem Generator

The use of the computer as a problem generator is not new, and the approach has been described and documented in many subject areas and for use at many different levels of instruction. The "wrinkle" we have added here is the convenience and accessability of the problem generator to the teacher. Rather than a slow and noisy teletype located elsewhere, the teacher now has a fast and quiet printer located in his or her office. With programs stored on cassette or mini-floppy disk a typical problem generating program can be entered into the computer in less than a minute and within a short time problem sets can be generated for all the students in the class.

Again an example from trigonometry will be used to illustrate the strategy. One of the major applications of trigonometry that is studied in virtually all courses in trigonometry is the use of trigonometric concepts to solve oblique-triangle problems, i.e. given three parts of a triangle, find the other three parts. It is at this point in the course that the Law of Sines and the Law of Cosines are introduced. The computerized problem generator is used at the end of the study of this section to evaluate student learning. The computer generates a unique problem set for each student requiring them to solve four oblique-triangle problems - one example of each type of problem we have studied. At the same time that the computer generates the problem set for the student, it generates the solution set for the instructor. To solve these problems the students are permitted to use their books, as well as their calculators. If they do poorly on the examination, they are given the opportunity to repeat the examination with a different problem set. Because each problem set is different, the students are permitted to take the examination when they are ready. There is virtually no way in which this same approach could conveniently be used without computer involvement. Furthermore having tried this approach using a teletype terminal, there is no comparison with the speed and convenience of the microprocessor based system.

The strategy lends itself to any subject area in which the random number feature of the computer can be used to generate problems. Included are courses in engineering, the physical sciences, accounting, and mathematics.

Summary and Conclusions

The two instructional strategies we have presented in this paper place the computer into an instructional role for which it is unquestionably well-suited. In this role it provides the instructor with technological assistance in completing tasks which he could not reasonably perform himself. To provide this assistance we require only a minimal computer facility - a personal computer, if you will - which is very cost effective. The instructor in using the computer, either as a computerized blackboard or as a problem generator, reaps maximum benefit. We find that used in this way the computer helps motivate the student; helps the student learn concepts more effectively; helps students reinforce learned concepts more efficiently; and even assists in the evaluation of the entire process of instruction. Using the term in its broadest sense, what more can we ask of computer-assisted-instruction?

It should be noted that neither of the above mentioned instructional strategies involves student use of the facility. It is the teacher who controls the usage of the computer, and it is to the teacher that the computer is dedicated. This represents a major departure from the "traditional" role of the computer in instruction. In presentations to educators from many different backgrounds, this author has found a far more positive reception of the potential of the computer in instruction when it is used in the context of the above instructional strategies. It must be made clear to educators that the computer is a tool of instruction for the teacher to use and not just the student. Student use of the computer is not precluded in this approach. Rather student use of the computer is simply one of the several possible alternative strategies which may be selected by the teacher under appropriate circumstances.

Large scale integration of microprocessor based systems together with reemphasis of the teacher's role in computer usage in schools may well be the key to the long awaited acceptance of the computer as a **primary** tool of instruction.

Champagne Quality CAI on a Beer Budget

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Most of you at this meeting are convinced that CAI can be an effective and efficient tool for teaching in a very wide spectrum of subject areas. It is likely that most of you have believed that for years. But the reality is that few if any CAI centers offer instruction that one would describe as effective and efficient in a wide spectrum of subject areas. If the basic assumption about the potential of CAI is correct, and we believe that it is, then there is a wide gap between the potential and the reality. The thesis of this paper is that recent and continuing developments in the manufacture of computer hardware make it possible to narrow or even close the gap.

Current CAI is hampered by deficiencies in three areas, hardware, systems software or languages, and courseware. Most CAI centers are using hardware which is too expensive for CAI, or which is not particularly suitable for CAI, or which is both of these. Many CAI centers are using a CAI language which is either inefficient, redundant, of limited power (i.e. obsolete), not suitable for CAI, or some combination of these. All CAI centers are short of quality courseware. Few of us would use textbooks which were as poorly developed as much of the CAI courseware in use. It is extremely difficult to write top quality courseware using a poor language for CAI; in most cases unsuitable systems software has led to inferior courseware. And in most cases the unsuitable systems software is used because of the limitations of the available hardware. Our conclusion from this brief analysis is that the current deficiencies of CAI are traceable ultimately to deficiencies in the hardware employed.

The current revolution in hardware manufacture can have a major impact on the qualitative and quantitative development of CAI. The revolution is not the downward spiral in the cost of hardware, although this will continue for at least a decade and will have important consequences for CAI. The revolution is the development of the microprocessor and its associated hardware. For about $50 more than the cost of a minimum feature CRT terminal CAI users now can purchase intelligent terminals (i.e. terminals with built-in microprocessors) which offer a range of screen control commands, vector graphics, and a variety of character sets. Some enterprising manufacturer could offer a state of the art CAI terminal including user-definable character sets, selective erase, vector and dot graphics with 512 X 256 resolution, and a touch panel for less than $1000. At these prices typewriter graphics and non-standard notation (e.g., lack of subscripts and superscripts) can no longer be described as characteristics of quality CAI. Of even greater significance for CAI development is the possibility of using a microcomputer-floppy disk system as the delivery device for CAI. The hardware (exclusive of terminal) for a system suitable for top quality CAI costs less than $2000. These prices have two major implications. First, almost any school or business can purchase a CAI system without seeking special funding. The possibilities for growth in the use of CAI are obvious. Second, computer hardware will be purchased solely for use in CAI. Under these conditions there is absolutely no reason to use unsuitable systems software. Rather, users can select a top-quality CAI language, and then purchase whatever hardware will implement that language. Under these conditions there should be a dramatic increase in the quality and the amount of CAI courseware being written.

The hardware for that scenario is available off-the-shelf. What about the systems software? The typical microcomputer comes with assembler and some - usually rudimentary - form of BASIC. Neither of these is a practical CAI language. PASCAL is gaining many adherents among small (and large) computer users, but it is not a CAI language. In fact the only CAI language which has been implemented on microcomputers is PILOT. Unfortunately there are a number of versions of PILOT in circulation,but there are only two versions available for microcomputers. The first of these is essentially the original version of PILOT as developed by Starkweather, Kamp, and associates at the San Francisco Medical Center. An 8080 implementation of this has been published in Dr. Dobbs Journal and is available from a number of user groups. The second version is a further development of extended PILOT as implemented at a number of institutions, most notably at Western Washington University. This second version is called COMMON PILOT. It is our contention that COMMON PILOT is a CAI language which can be used to implement courseware of the highest quality on microcomputers and that it is the only currently-available language which can do so.

The appendix to this paper contains a summary of the features of COMMON PILOT, and an author's manual is available. Here we only describe those features which distinguish the language from others and which justify our contention. COMMON PILOT is an interpretive language. This has two important consequences. First, the only limit on course length and branching complexity is the capacity of the disk which is at least several thousand lines. Thus the available memory imposes no restriction on course size. Second, it is possible to create and execute a COMMON PILOT instruction during a course. Among the benefits of this feature is the ability to incorporate random selection of text into verbal problems in the same way that random numbers are used in mathematical problems. (In numerical problems an answer comparison must be generated from a random number; in verbal problem an answer comparison must be generated from randomly selected text.) COMMON PILOT includes a full range of string, floating point, scientific functions, as well as vectors and matrices. String arrays are replaced by substrings of strings with maximum length 1000. COMMON PILOT has a very powerful matching algorithm for answer judging. Answer judging beyond the capabilities of the algorithm can be handled using the string and numerical operations provided. COMMON PILOT is not designed for implementation of any particular teaching strategy; correct and incorrect answers are not automatically counted, responses are not automatically timed, statistics are not automatically kept. The advantages of this are efficiency of use of computer resources and generality. All teaching strategies can be implemented. Of course an author can use the numerical operations to keep statistics where desired. Finally it is important to mention that COMMON PILOT is efficient enough to give good to excellent response time on standard microcomputers. When such a language is a practicality on the cheapest available hardware, there seems to be little reason to settle for less.

Obviously it would be desirable to agree on a national standard for one or a few CAI languages suitable for microcomputers. There is some interest in setting a standard for an extended version of PILOT, and COMMON PILOT has many supporters among those interested in standardization. Unfortunately, standardization is a very slow process unless backed by a major supporter. Perhaps the available mechanisms are simply too slow to cope with the microcomputer revolution. Whatever the reason, no progress towards standardization of PILOT has occurred since an early version of COMMON PILOT was circulated among the interested parties at last year's ADCIS meeting. Therefore we are attempting to set an unofficial standard by implementing identical versions of COMMON PILOT on the largest number of machines we can. This is a cooperative effort between WWU and a private firm, Micropi. Crucial to this effort is a COMMON PILOT interpreter written in PASCAL. That interpreter, which is now completed and tested, is crucial because each new microprocessor probably will run PASCAL upon release. Thus we believe that COMMON PILOT will run in identical versions on all new microprocessors without extensive assembler programming. In addition we have completed versions for the 6800 (available from SwTPC), the 8080 and Z80 under North Star DOS and under CP/M (available from Micropi), and the Odell (available from VANDATA). We currently are working on versions for the Radio Shack TRS-80 (Micropi), the Terak (Micropi); and for large machine users the CDC 6400 (WWU and the University of Washington) and the Amdal (WWU and Washington State University).* In summary we can support the claim that COMMON PILOT offers the possibility for writing and delivering champagne quality CAI on a wide variety of existing hardware and further that courseware written in COMMON PILOT will run on the new microprocessors as they become available.

We also should justify the "beer budget" in our title. To do so we simply list the hardware necessary for two typical systems. We stress typical, these should not be construed as recommendations.

North Star Horizon (32 K, Dual Mini-floppy)	2800
SwTPC Intelligent Terminal	800
	3600

SwTPC 6800/2 (24K, Calculator)	1100
SwTPC Dual Mini-floppy	1000
SwTPC Intelligent Terminal	800
	2900

The latter system offers the interesting possibility of expansion to up to 4 terminals by adding some memory and perhaps upgrading the disk. In this configuration the response will be somewhat sluggish in applications involving lengthy computation, but that will be aleviated by replacement of the CPU board with a 6809 board. The cost of this configuration would be less than $1800 per port including systems software! That's beer budget.

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* Completion of the latter two will establish an effective standard for COMMON PILOT throughout the State of Washington.

To conclude we should give our predictions about future developments. However the microcomputer field is moving so quickly that guesses as to the future made when this manuscript is being written (Nov.) are likely to appear dated by the time it is read.

Appendix

PILOT LANGUAGE SUMMARY

LABELS

--must begin with an *
--one to six alphanumeric characters
--first character must be alphabetic

OP CODES

PR: option list

Option List

U - upper case
S - remove spaces
E - escape allowed

L - lower case
G - Goto allowed
W - clear label table

R: remark
T: type text
A: accept answer
M: match answer
J: jump
U: use subroutine
E: end subroutine or program
C: compute a computational language statement or EDIT a string
XI: execute indirect
FI: file input
FO: file output
: Type text continuation
D: dimension
G: graphic output

MATCH INSTRUCTION SPECIAL CHARACTERS

* match any single character
% match a space or answer start or end
& AND -- match one word *and* another
! OR -- match one word *or* another

MODIFIERS

H	Suppress line feed with Type (TH:)
J	Automatic jump with Match (MJ:)
S	Spelling correction on Match (MS:)
X	Suppress input text editing (AX:)

EDIT OPTIONS (C: /B$ options)

C	Capitalize first letter
U	Translate string to upper case
\XY	Replace all character X by character Y
\X\	Remove all occurances of character X

CONDITIONERS

Y	Execute if yes match
N	Execute if no match
n	Digit conditioner, execute if match with Answer counter
E	Execute if error condition set
C	Execute if last relational expression true

RELATIONAL EXPRESSIONS

op-code (relational): text --Execute instruction only if relational expression is true (nonzero) (BASIC syntax)

EXECUTION TIME COMMANDS

GOTO - Jump to new location
@ any text - escape to subroutine SYSX

COMPUTATIONAL FEATURES VALID ON C: OP CODE OR RELATIONAL EXPRESSIONS

Floating point scalar variables, arrays, varying length strings

+ - * \ ** ||

= < > <   > <= >=

& ~ !

ABS FIX INT SGN RND SIN COS ATN SQR EXP LOG

LN STR FLO ASC CHR LEN INS

SYSTEM VARIABLES

%A (Answer counter)   %B (Answer buffer)

SUBSCRIPTING

Single Dimension Array

X(N)   N may be a variable or constant 0-999

X(N,N)

String

A$(P)   P=Position

A$(P,L)   L=Length

GRAPHICS OPERANDS

S(R,C) - Set screen scale to R rows by C columns

P(R,C) - Position cursor

L(R,C,R,C) - Draw vector

E(R,C,R,C) - Erase vector

D(R,C,V) - Dot at R,C to value V

V=0 off
V=1 on
V=2-9 colors

X(n,n....) - Transmit control characters (n is 0 to 255)

C - Clear screen

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TEACHERS TAKING A BYTE OUT OF AN APPLE

All was in darkness. On the first day, Van Neuman proposed the computer and there was light. On the second day, Grace Hooper advanced the proposition of higher level languages. On the third day, others advanced the proposition that all languages are not created equal. On the fourth day, the concept of an "author language" was conceived, and on the fifth day, Coursewriter was born. On the sixth day, much courseware was developed in Coursewriter and its offspring: TUTOR, IDF, and DECAL. On the seventh day, computer and teacher (who was by now thoroughly exhausted) rested.

The above scenario, although not strictly according to fact, does convey the spirit of the movement from machine language to author language. It also, hopefully, makes the point that author languages can be debilitating because of their versatility. Many teachers, particularly those in the humanities, WILL NOT write materials in a language which forces them into a mold they consider inhumane or which, through sheer complexity, overwhelms them.

In 1973, Dr. John Starkweather of the University of California in San Francisco, saw a clear need to alleviate some of the above pain. His solution was a proposed language which fulfilled the main requirements of an author language while remaining elegantly simple. This language was called PILOT or Programmed Inquiry, Learning or Teaching. The language was initially implemented as an interpreter in PL/1 and has since been rewritten for other operating systems in HP BASIC, DEC BASIC PLUS, FORTRAN II, and a multitude of other high level languages as well as machine languages.

Starkweather's original conception has proved extremely durable and able to weather these translations. In addition, some material originally written in Coursewriter at UCSF, Western Washington University and other schools have been translated into PILOT. Academic authors have, almost without exception, been delighted at the ease of learning and use of PILOT.

In 1976, Dr. Starkweather received a contract from the National Library of Medicine to implement PILOT on a microcomputer. Because of its then current availability and popularity, he chose to work with the INTEL 8080 chip.

A version of PILOT containing all of the commands of CORE PILOT along with appropriate error messages, diagnostics, editing capabilities, and I/O patching was implemented. Since that time, PILOT has been implemented on 6800 based systems, such as that of Southwest Technical Products Company, on Z-80 based systems, such as the Radio Shack TRS-80, and on 6502 based systems. The present implementation is on the 6502 based microcomputer, the APPLE II.

A core set of PILOT instructions was agreed upon in 1973. The set of instructions allow diser input, computer output, comparison of input against stored answers, control statements and minimal computational ability. Other statement types to be added when PILOT is standardized are graphics and chaining statements.

This implementation covers the basic commands: TYPE, ANSWER, MATCH, JUMP, USE, COMPUTE, END and REMARK. In addition, full access to the low resolution graphic capabilities of the APPLE have been provided as well as a subroutine to produce musical tones. A large base of quality educational material developed by a group of teachers and instructional designers has been modified for use on the APPLE II. Some of these materials have been adapted to PILOT, although originally implemented in BASIC or IDF.

The present study is concerned with the use of PILOT with elementary school children. The specific area of investigation is that of improvement of self-concept in students using the micro-computer as compared with students who are using other instructional media. Tentative results will be reported at the conference in February.

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Beyond Independence: A View of Games and Personal Computing

Abstract

Personal computing and interactive computer games are presented as two concepts which have a great deal to offer one another. The rationale for each is discussed, stressing the importance of the feeling of independence for the personal computer user. An extensive list of games, competitive and cooperative, is given as an initial attraction to draw many individuals into the home computer market. Many of the games and other interactive applications were created by people who had grown weary of playing Startrek for months on end. It is suggested that other personal computer users will also tire of playing games solely, and will begin to create their own processes. Based on the present, it appears the future will see considerable sharing of efforts among users of personal computers, perhaps within the framework of a network.

I. Introduction

Independence! What overwhelmingly deep and warm (sometimes scary) feelings are evoked from most people when this word is spoken in sincerity. It is my opinion that this value, in conjunction with the technological miracle of the microcomputer, is largely responsible for the revolution we are seeing today in computing. The other trait which contributes to the revolution of personal computing is that of curiosity, and is most obvious in the initial attraction of a person to an interactive computer game. In this paper, I will discuss the interaction between games and personal computing, why we have then now, including an extensive list of the former, where we may be going from here and why I hope to see a growth beyond the strongly-held value of independence to that of an interdependent community of personal computing users.

II. Why Do We Have Them?

A. Games

Games are fun! That's hardly a surprise -- We've known they are fun since we were old enough to play our first one. Perhaps games, play,and fun are all synonymous. They pique our curiosity, and encourage us to explore uncertain situations without fear. Computer games permit one or more persons to play each other over distances using the machines. They will play with us alone in case sister Sue or uncle Bob is unwilling or unable to play right now, and the diversity and complexity of the games is remarkable. There are other, perhaps more pedantic reasons, why we are attracted to games on computers. They allow us to develop our problem-solving skills in a non-threatening environment. Many of us are anxious to demonstrate our superiority over the computer, the clock, or other players. This competitive aspect is very strong in many (most?) games.

B. Personal Computers

A person in the United States today who does not know something about computers is either illiterate or lives in isolation. The impact of computers is felt nationwide and frequently worldwide. Yet many (most?) people feel alienated and threatened by such machines. This alienation may be on the verge of breaking down, in my opinion, thanks to the ingenuity of microcomputer designers and the marketing skill of businesses, small and large.

The advent of the personal computer in retail outlets nationwide for a price comparable to a good color television set or stereo console is a major step in the revolution of bringing computer power to the people. When Joan or Joe Smith have their own personal computer, they are unlikely to be as intimidated as now when they are told, "It's the computer's fault" by Sears, Mastercharge, Consolidated Edison, California State University, United Airlines, Union Bank, General Motors, the property tax assessor, Department of Motor Vehicles, or the Social Security Administration.

A personal computer signifies that an individual is no longer solely dependent upon what he or she is told by the computer belonging to a large, seemingly insensitive institutuion. And, to no one's surprise, people like that! To be more independent of big business, big government, and big education is a value sought tirelessly by many people. The computional power once available only to big establishments for millions of dollars is now readily available to most of the general population for roughly $1,000, and the price continues to decrease.

III. The Hook

We are all familiar with the story of how the staff at the carnival sideshows would secure their customers. To feel oneself being dragged to the entrance by a hook caught in a collar or sleeve is a powerful inducement to attend the show!

The moral is clear - just the availability of carnival marvels or technological marvels such as the personal computers discussed previously

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does nothing to quarantee customer response. You need a hook!

Well, the burgeoning individually owned or franchised computer stores, and soon the large retail outlets, have just such a "hook". It is called "playing games on the computer". This technique is a superb way to attract a customer initially, given a near universal propensity for games. And, of course, the larger and more diverse and more complex the stock of computer games, the more interest will be generated by the customer, soon to be purchaser, of her or his own personal computer. There is also a substantial portion of buyers who have additonal reasons; we shall return to this class in the next section.

In this seciton, I will list some of the games which I have used as a "hook" in introductory computer science classes for several years. In my opinion, they would be ideal to implement on personal computing systems (several have been) as they are interactive, written in Basic (95%), and extensively tested. It will be obvious that most of the ones listed under games have been published in Creative Computing, Personal Computing, Interface Age, Byte, Kilobaud, People's Computers, etc. A few come from other sources (6), some from myself, and many were written by students who had been "hooked." As most computer science faculty are aware, there are always a few students who are exceptionally clever, witty, and thorough in creating interactive programs. Several of their term projects are included in the list. The entries are taken verbatim from a larger set of program descriptions handed out to students at the beginning of the term.

Program Names and Descriptions

(All programs are interactive, unless otherwise noted.)

A. Applications

NAME	DESCRIPTION
220GRA	Determines grade as function of units passed, final, and project Message file for CS220
220NEWS	Derives a family budget in an interactive fashion
CRONY	Introduction to KRONOS system
OSGRADE	Instructor Grading for CS220
GENES	Genetic Simulation (not interactive) (Fortran source is in unit record room by computer center)
LINEAR	Linear Regression
LYNN	Projectile Physics "Game"
MATHREV	Review of elementary arithmatic for junior high level.

SCBASIC	Structured program preprocessor for Basic
SIMULT	Simultaneous Equations
TREES	Tree identification

B. Personal Data Bases and Questionnaires

NAME	DESCRIPTION
DTBS	CS220 Project on personal information
FUTURES	Delphi questionaire on computer impact
FUTURAN	Analysis of responses from FUTURES
QUERY	"Interviews" beginning students in personal fashion, letting them ask questions
SEC	Discussion of computer security and privacy issues
SCABBYS	CS20 project for keeping records on players of Star Trek game
SOCIETY	Questionaire from Creative Computing on computer impact
ULTIMAT	CS220 Project for privacy of personal data bases

C. Simulations and Models

2001	A student's view of his day in the year 2001
WORLD	Extensive technologically optimistic simulation of world (Forrestor's model)
WORLDM	Simple world simulation model (graphic output)

D. GAMES

BAGELS	Number guessing

BATNUM	Variant of NIM-Battle numbers
BULLRUN	Simulation of Civil War battles
DAMON	Computer Dating
DATE4U	Computer Dating Matches (not interactive)
DAYTONA	Choose car type and racing style
DODGEM	Try to cross a board before opponent
DRAG	Design your own dragster
FTBLL	Extensive football game
GAL	Command Galileo shuttlecraft of Starship Enterprise
GAMES	Extensive index to games
HAMURBI	Govern ancient Sumaria
HANGMAN	Word guessing
ICBM	Intercontinental missile game
INDEX	Major index for games, programming lessons, notefiles, etc.
LOST	Cooperative game of being lost on gold-filled island
MADLIB	Lets group of users make up riotous stories
MONSTER	Don't get eaten!
OLDMAID	Classic card game
RACE	Choose your car in road rally
REVERSE	Sorting game with numbers
RIDDLES	Just what it says!
SLOTMAC	Win a fortune on a slot machine
SPILL	Spill and Spell game to make words from random letters
STRBS	Protect your starbase
TREK	Star Trek

WUMPUS	Hunt the wumpus in a weird scary cave
XB70	Star Trek

E. Graphics

GARYPIC	Portrait of Gary Jerep
LOVE	Robert Indiana's love poster
PIC	Draws arbitrary picture
SINE	Sketches sine curve
SNOPIC	Snow and mountain picture
SURFACE	Three-dimensional plot of math function
WORMY	Watch a worm chew up a garden
XMAS	Portrait of Mary and baby Jesus

For some time, I have been concerned with the emphasis placed on competition in several facets of education and computers (8,9). Even prior to compiling the above lists, a major point was obvious to me: playing a game and competing are *not* synonymous concepts. Yet how often do we treat them as the same? When we are asked to play a game, either by a person or a computer, don't we automatically *assume* they mean a zero-sum game, i.e., if one person wins, the other loses? Yet if we go to the American Heritage Dictionary, we find the following:

> "game: 1. A way of amusing oneself; a pastime; diversion. 2. (Mathematics) A set of rules completely specifying a competition . . . 3. A sport or other competitive activity governed by specific rules." (11)

Although games *may* be competitive, the concepts are not identical. In our world of today, I believe that the concept of *cooperation*, rather than competition, should receive increasing emphasis. The reasons for this desire to work with a community of responsible individuals toward a mutual goal are detailed elsewhere (8). Also given in the same paper is how cooperation has been included explicitly in several of my computer science courses. Summarizing, it was done in five ways:

1) study partners for the units of a personalized system of instruction (PSI) course,

2) mutual design and use of interactive programs assigned in the units,

3) use of cooperative exercises, computer and otherwise,

4) parties, and

5) design of a computerized personal database by a small group.

The results of point 5 above are seen partially in the extensive programs listed earlier under "Personal Data Bases" (DTBS, FUTURES, FUTURAN, SCABBYS, ULTIMAT) and "Games" (GAMES, INDEX). These are systems which one may use "to amuse oneself, as a pastime, a diversion", and yet are not solely competitive. They were designed and implemented cooperatively, using reliable techniques such as structured design and programming, top-down design for games (5), and "egoless" programming (2). They are not the same as cooperative games, e.g., LOST or MADLIB. The latter class is very difficult for most of us to even conceive - can you give me the names of just five games which are based on cooperation? I'd be delighted if you could provide me a source for one! Compare the difficulty of that request with one for a source of our most popular (competitive) game - STARTREK. And yet, what role did competition really play in the original television show? As Douglas Crockford pointed out recently, the mission of the Enterprise was to : "seek out new worlds and civilizations, and to go where no man had gone before", not to blast Klingons out the galaxy (3).

Games for computers then are a useful "hook" to interest people and to provide an initial contact which, hopefully, is non-threatening to most. Competitive games can be fun, but we can also begin to offer games in which someone does not have to "lose" in order for someone to "win". Moreover, we have further evidence that people can design and implement fun-type programs in a cooperative manner. This will become increasingly important as we move further along in the personal computing revolution.

IV. Where Do We Go From Here?

For sometime now, I have been struck with the remarkable analogy of how an individual relates to his or her private automobile, and what the future may portend for how an individual relates to his or her personal computer. When we acquire our first car, how much of our time with it is spent in games, particularly competitive ones, e.g., purchase price, 0-50 time, miles per gallon (rare!), engine size, interior, paint job, mags? Sure, we use it in a cooperative fashion once in a while, e.g., taking the other kids to school, but was that the real reason we purchased it? And then, after the purchase, a few of us are actually sufficiently motivated and clever enough to open the hood and build or rebuild parts here and there. Some people continue this interest for most of their life, through one car after another. Yet most of us are content to let someone else maintain and repair the vehicle after a short time. The private car as a technological miracle of the early 20th century is a superb example of independence, or at least semi-independence, as the recent oil boycotts have shown. The pervasiveness and widespread distribution throughout our culture of this product constitute a ringing testimony to our belief of going where we want and when we want. It is truly a remarkable extension of our ability to walk. Such a concept of independence is certainly not lost on the more centralized carriers of people, e.g., railroads, planes, busses: just note their "freedom fares" or the "go anyplace, anytime fares."

It would not be difficult for anyone familiar with personal computing to rewrite the above paragraph, replacing automotive references with personal computing ones. The analogy is striking. We become hooked on computer games (most of us). We purchase our machine and play Startrek for six consecutive months, perhaps taking time out to use it for pre-programmed mundane tasks such as family budgeting. A few of us (many of us right now because of the relatively small population) actually tinker with the insides adding a CPU (engine) here, putting on paddle controllers or voice synthesizers (4-barrel carbs or mags) there. I certainly think the "tinkering" with microcomputers will contribute much more to future computer design than does current "tinkering" with cars for future car design. This is *not* an attempt to put down kit-builders or designers; it *is* an attempt to say I do not believe many people wil do it, no more than most of us would do serious work on our car.

However, the analogy begins to break down at this point. For there is a vital distinction between a personal car and a personal computer. If you want to change the latter, you do *not* have to tinker with hardware. You can build yourself a new (virtual) machine by composing programs. Initially, I would not expect a large proportion of the owners of personal computers to take such a task upon themselves, unless of course, they knew about programming before. But as the hardware and particularly the system software improves, I expect the complexity of the user interface to decline. Although natural language is still not in the immediate future, there are processors available which are considerably easier than those you and I learned. Apple Corporation's version of Basic permits three-dimensional color graphics (15). Logic Machine Corporation's ADAM bears very little resemblance to the strict procedural languages known to most of us (7). By the time this paper is presented, other non-rigid user interfaces will certainly have appeared. And I would wager that many of these interfaces will have their origin with the owners of personal computers or institutions which are firmly committed to the concept of "Computer Power to the People."

The importance of making it easier for the personal computer owner to program will become abundantly clear to her or him after the six months of Startrek and running the few non-game programs from the cassette tape purchased along with the machine. Now, if the machine belonged to someone else, it might well cease to be used at this point. However, a person who has made a substantial investment will not be so likely to simply leave it turned off.

I believe personal computer owners will begin to generate useful programs, initially for their own purpose, but later for the neighboring community. Substantiation for this is not difficult. How many of us know students who eventually tire of playing games solely over the interactive terminals, and begin to write extremely clever and stimulating computer-based eudcation (CBE) lessons? Witness the popularity of the "Lemonade Computer Service Company" articles in *Personal Computing* (12), whose intent is to show how home computers can be used for small businesses ("lemonade stands and paper routes"). In the first issue of ROM (14). Hesh Wiener relates how he was able to turn his teletype into a braille - printing terminal in six hours, and now has trouble getting his blind friends off his computer. Although hardly a personal computer in price, PLATO provides an excellent example of how former game-playing students now write some of the best CBE lessons (10). The programs listed in section III included many written by students, both of a game nature (FTBLL, OLDMAID, BATNUM, SLOTMAC, SPILL), and those which are application-oriented (CRONY, CSGRADE, LINEAR, LYNN, MATHREV, SIMULT, TREES). All of these were written by students on interactive systems owned by a university, i.e., they had to compete with hundreds of other users even to use the terminals. It is exciting indeed to contemplate what may happen when many of the same students, as well as many of us, have virtually unlimited access to personal systems. Where we are going is, of course, anyone's guess. I believe that providing increasingly better human interfaces, languages and hardware, on personal computers will reap enormous benefis in terms of application programs for use by the individual user and the community at large. This "equalizer," a term from the pages of Personal Computing, finally begins to offer individuals some of the remarkable symbol-processing power available to large institutions for the last twenty years. The amplification of some of our cognitive abilities offered by personal computing will, I believe, be at least as significant as the amplification of some of our locomotion abilities offered by personal cars.

V. And, Finally, How Do We Go From Here To There?

The mere availability of application programs on personal computers will do very little to guarantee that they will be used. The identical point was made earlier with regard to simply making microcomputers available. Consequently, personal computer owners who have written programs for the use of their family only will most likely be prodded, either internally or by their neighbors, to make their computer facilities more widely used. This problem of distributing a product is an old one, but usually so for businesses; individuals do not have much experience with the concept as a supplier of the product, only as a recipient.

There is a distinctive quality about the products which are now distributed by people involved in personal computing. An enormous amount of it is free, or virtually free! The quality of interdependence: "I created something; I'll share it with you; perhaps you'll share something with me" is one which underlies many interchanges of knowledge and/or products. We realize fully that asking a high price for our product will prohibit its distribution. So the concept of mutual cooperation is one that is everywhere evident in personal computing. I believe it is an excellent and appropriate model in comparison to the competitive one with which we are all too familiar. And it is a natural growth from the model of strict independence. This same transiton from competition to independence to interdependence is one traced in education in an earlier reference (8).

Now sharing one's efforts is oftentimes easier said than done. There are currently at least four major routes used:

1. Publications. Send a listing of your program and associated documentation to a magazine publisher. Many of the magazines are listed in the bibliography.

2. Removable storage media. Send or sell cassette tapes or floppy disks to a person requesting a program. Most computer stores do this. See also the September, 1977 issue for Interface Age (13).

3. Centralized time-sharing systems. Give the requestor the password to use your program stored in a centralized data base. PLATO is an excellent example of this.

4. Networks. Send your program over communication links to another computer or let the remote user access your program. The ARPANET is an obvious example.

Each method has its own advantages and disadvantages, but one of the most serious concerns in all is portability (is probably of least concern in type 3). Given the predisposition of personal computer owners for independence and the ready availability of the telephone network, I strongly imagine alternative 4, networks, will become increasingly common. The Personal Computing Network (PCNET) started in the Palo Alto, California area is an excellent example (1). Of course, these communications lines are for computers. Also of vital importance is the communication lines between personal computer owners and people in the community having no such machine. The latter is particularly exciting, in my opinion. Peoples Computer Company in Menlo Park, California staffed a Community Computer Center to bridge just such a gap (4).

VI. Summary

In conclusion, I have tried to indicate why I believe the advent of the personal computer portends a true revolution for much of our culture. There is an enormous appeal for a technological product when it can be utilized extensively by an individual person or family unit. Witness the popularity of calculators, cars, televisions, radios, houses, and solar energy collectors, to name but a few. Most people are extremely interested in artifacts which allow them to decrease their reliance on large institutions, i.e., those items which seemingly increase the abilities and independence of the owner. I have indicated that computer games of all types: competitive, cooperative, and application could well be used, as they have been, to increase the interest in personal computing. However, it appears that games are not sufficient stimulus over the long-term, and so I believe personal computing users will grow beyond games. They will become increasingly interested in and capable of constructing their own processes, some games and some applications. The literature indicates this is already occurring. Some of the resulting programs will be used primarily for the needs of the owner, but I believe a considerable amount of the effort will be shared with other personal computer owners. This sharing has occurred initially by publications and removable storage media, but networks will probably appear with increasing frequency. Moreover, there will be considerable sharing between those who own the machines and those who do not, yet! I fully expect the former class to grow dramatically in the next decade. It promises to be an exciting one for us as an interdependent community of individuals.

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COURSEWARE DEVELOPMENT FOR MICRO-COMPUTER BASED EDUCATION IN MUSIC

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In pressing the search for an economic solution to the hardware necessary to deliver high-quality instruction in music education, this report is an update of an innovative application of developing stand-alone microprocessor technology to music instruction. In a paper by Peters (1976), the importance of a viable operating system was outlined both for a small computer system, as well as a very large system with music peripherals.

To date most successful CBE applications in music have been conducted on large to mid-sized computers with all the advantages and disadvantages linked to the large computer concept. The development of a stand-alone system for teaching music is timely, in that the marketplace now offers numerous types of computer devices from which to select and choose to design an operating "system". Although most major components of the system have been available previously, the synthesis of hardware and software into an operational system is viewed as a major step toward making CBE a more economic avenue to learning. Several technical problems were resolved in developing approaches to hardware and software selection for the system that has evolved.

When first conceived, the idea of using smaller computers for music instruction yields obvious advantages attributed to stand-alone operations. In light of the desired operation of hardware for music instruction, many small computers and even mid-sized computers have not been able to process the required instruction set. Using a pre-determined list of criteria, the investigation of available hardware was limited to recently developed microprocessors that could support music peripherals in an instructional mode.

Purpose:

The purpose of this research project was to investigate the feasibility of the application of microprocessor technology to computer-based education in music. Two questions were considered in this investigation:

1. What hardware is available to develop a viable microcomputer system capable of:

   a) supporting music peripherals
   b) displaying requisite music notation and graphics
   c) maintaining and delivering instructional materials

2. What useable computer language should be used to operate selected hardware that is:

   a) commonly in wide use by micro-computer programmers
   b) capable of supporting graphic displays and music notation
   c) capable of operating music peripheral devices as part of the instructional system

Using the Peters "complete-music-system" concept as a blueprint, the investigation was conducted to determine if technology had advanced to the point where the novice could purchase equipment capable of supporting music instruction, with little developmental difficulty.

The music system was to include a four-voice tone generator, a tape playback system, touch input, graphics display, slides, (optional) and stand-alone capabilities. The added requirements of analog-to-digital input and a keyboard were also considered desirable optional equipment for the microprocessor music system.

Procedures:

A survey of recent articles and reports on the development of programing and microprocessors yielded several possible avenues of investigation. A project by Mabry, et. al. (1978) dealt with similar interests in the field of medical instruction. This developmental research demonstrated the ability to operate a PLATO IV terminal on an IMSAI microprocessor with a hybrid language NSBASIC (Not-So BASIC) written by Tucker.

Since the Mabry project had retained to PLATO IV graphics capabilities, the judging of interactive responses and "primitive" data management, non-graphics systems were dropped from the investigation. The added development of the PLATO V terminal by Stifle (1977) combined the microprocessor capabilities with the PLATO IV terminal. Gooch (1978) cites the "8080 microprocessor system in the PLATO V terminals is capable of executing programs locally. It can also be connected directly to terminal-peripheral devices. . .this terminal architecture makes possible coding, buffering and local processing." Gooch utilized the microprocessor for added computational power in the development of his music synthesizer which was not conceived as a stand-alone system.

The development of a stand-alone PLATO IV system and the support of music peripherals by a PLATO V terminal which contained a resident microprocessor indicated that technology was available to meet the instructional demands of music.

To direct the investigation of hardware and software appropriate to the development of a micro-music-system, several approaches were considered. The approach of simply searching for available systems was discarded in favor of first determining minimum, requisite functions necessary to operate the "model system" and "model music lessons".

The power of the language and the processor was considered against the demands of four "typical" graphics music programs:

1. music notation lesson with animation
2. ear-training lesson, requiring sound generation
3. random-access tape playback lesson
4. visual color-slide lesson in music pedagogy

The investigation of the available hardware and computer languages were combined for the most part. A processor/language combination capable of presenting the four programs was deemed "acceptable". As a point of comparison, lessons were selected from the available PLATO IV music lesson catalog in each area for quality standards.

Computer language packages in most cases have been developed with a specific processor in mind. Microprocessors of similar capacity normally were found to have similar available operational options. The search for "PLATO-quality" graphics limited the investigation of hardware to systems that would support graphics terminals. With the available PLATO V hardware as a programable terminal, attention was directed to its possible stand-alone operation.

Early attempts at writing music courseware were conducted on a modified PLATO V terminal developed by Carroll Manufacturing Company. The INTEL 8080 microprocessor could be programmed in several modes including assembler language and an experimental version of TUTOR named MICROTUTOR which has been developed by Andersen. An ear-training lesson was developed as a MICROTUTOR lesson and partially as an assembler language lesson. When the first two lessons were written for evaluation, the decision was made to use a very early version of MICROTUTOR.

The experimental lessons that were developed for evaluation could be down-loaded from the PLATO network computer to the terminal and used as terminal-resident lessons. Once the lesson was loaded to the terminal, the computer could be disconnected during the operation. Later versions of the lessons could be transferred to the Carroll terminal from cassette tape. The loading process was longer than desired, but the process demonstrated the ability to operate an instructional lesson with no interaction from the large PLATO computer.

At this point in the project, hardware and software was found acceptable for the delivery of music lessons which required music peripherals. The version of the computer language was difficult to use as compared to the normal TUTOR language. Slight hardware alterations were necessary to operate the terminal when disconnected from the computer network. The major disadvantage was one of lesson length. A drill lesson could be written that would randomly play ear-training exercises for an hour. If lessons required many written or graphics displays, the lesson length was much shorter than the forty-five minute to one hour length desired. A hardware limitation of approximately 4000 eight-bit words of lesson material could be loaded for instruction. In an interactive mode with the computer network, additional lesson material could be loaded quickly, as required by the student. This option was not available in the stand-alone mode of operation.

Four lessons were written to demonstrate the capability of operating the four-voice tone generator, the random-access tape playback system, and the random-access microfiche slides, plus music notation animation. Each lesson was a short demonstration which was interactive and instructional. These lessons were completed during the Spring of 1978 for a stand-alone operation.

Discussion:

The investigation of hardware and software available to the consumer has pointed to major differences in the developmental purposes of computer systems. The first glaring difference observed is that between the computer "toys" and computer "tools". Special function microprocessors exist in both areas and can be equally difficult to modify to operate in music processing. Computers that do have audio output capabilities normally have not been developed to satisfy the musician's expectation of fidelity or intonation.

The second dichotomy is found between the literature, hardware and software developed for the hobbyist and that for the computer specialist. The hobbyist approaches the microprocessor as an evolving system and is willing to cope with continual up-grading of a "home" computer. The computer specialist is looking for an operational system that is highly developed and dependable.

The third difference is found between the instructional and non-instructional applications of the computers or microprocessors. A computer system can be highly effective in a non-instructional mode and fail rather elementary criteria necessary for good instructional presentation. The speed that information is displayed and the quickness that responses (input) can be processed is significant, when considering instructional applications.

To select a successful microprocessor for instructional purposes, a professional quality, computer tool should be selected. Preference should be given to processors and languages that can support rapid displays with satisfactory processing time. In the field of music, graphics capabilities are essential. The quality of the music notational characters is equally critical. If the representation of music characters becomes too abstract (the letter "d" for a "𝅗𝅥"), the music student is forced to learn new, unnecessary sets of representative symbols.

Although this project resulted in the selection of PLATO-compatible hardware and software, several other microprocessors were found capable of supporting satisfactory music instruction. Surveys by Dennis (1977) and others indicate that BASIC and MINI-BASIC are considered very popular languages for instructional purposes. Several eight-bit processors and new sixteen-bit processors are available to the researcher.

Evaluation:

The evaluation of the hardware/software system developed in this project was based upon the capability of displaying four music lessons requiring peripheral equipment. If a system could be found that would run high-quality instructional programs, the results of the investigation would be considered positive.

The lessons developed for the stand-alone music system were considered satisfactory and equivalent to PLATO IV lessons requiring similar peripheral equipment. The advantage of the terminal-resident lessons was noted in the very rapid display of information on the computer terminal screen. The obvious advantages of single-user operations was evidenced in seemingly instantaneous key-processing. The interaction response-time was so fast that one lesson was written with a time-delay before processing was displayed to the student. Additional research in response-time displays is recommended.

Conclusions:

The ease of developing micro-lessons on a large computer was noted as significant. The pilot programs developed for this project indicate successful translation of programs written on a large computer mainframe to a microprocessor. From the early experimental lesson results, a stand-alone microprocessor unit has the demonstrated capacity to support high-quality computer-based education in music.

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PROJECT CLEF: CAI IN MUSIC THEORY
- UPDATE 1979 -

by

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PROJECT CLEF refers to the development, since 1967, of Computer-Assisted Instructional Programs in Music Theory at the State University of New York, Potsdam. Development has primarily involved SUNY Potsdam personnel from the Computer Science Department and the Crane School of Music, and has used on-campus equipment. Early thrusts of the Project, including then current directions, were reported in a paper entitled "PROJECT CLEF: CAI IN MUSIC THEORY; Paradigms, Potential, Problems" presented at the Fourth Conference on Computers in the Undergraduate Curricula (CCUC/4), Clarement, California, June 1973.

Ensuing developments have included interfacing a Thomas electronic organ with the on-campus IBM Systems 360/30 and 360/40, and preparing the input notation for CHORDAL I (called SIMPLEX CODE), based on PL/1. This notation is designed to enable authors to write musical examples for organ output, in an interactive environment with dialogue format.

Since early 1978, the principal efforts have been to develop, test and implement on a minicomputer the pedagogical capabilities designed earlier on the larger systems, including a more accessible version of the interactive software. (See Fig. 1). The teaching and file building segments of the software package, including the revised SIMPLEX code, are based on an extended version of FORTRAN IV, and are currently referred to as "CHORDAL II".

Hardware

The basic configuration for the current phase of PROJECT CLEF includes: Interdata System 7/16 (32 KB) with two casettes and one disc drive; CRT; TTY; current loop interface enabling the two terminals to be operated simultaneously; Conn electronic organ (two manuals and pedal clavier); organ interface.

Software

Because FORTRAN was the only high-level programming language available with this system, it was chosen as the primary language for the CAI programs. The Interdata FORTRAN compiler has many features similar to FORTRAN compilers on the IBM Systems 360, thus it was possible to develop and test programs on the 360 in batch mode before attempting to run them interactively on the smaller system. Supporting software on the 360 included XFORT, a structured FORTRAN preprocessor which allows the user to write a program with IF-THEN-ELSE and WHILE-DO and then translates the user's program into standard FORTRAN with IFs and GO TOs. Thus the programs were written in structured FORTRAN, translated into standard FORTRAN by XFORT and tested on the IBM 360 before being run on the Interdata 7/16. (See Fig. 2). Certain subroutines, such as input/output to the terminals and the disc, character and bit manipulation, and output to the electronic organ, were written in assembly language for the Interdata and then rewritten in FORTRAN for testing on the IBM 360.

Programming

The basic format for Computer-Assisted Instruction in PROJECT CLEF is to have the computer present a question to the student, accompanied by notes played on the organ. The computer then compares the student's answer with a list of expected answers and types an appropriate response to the student. If the student's answer is correct, the next question is asked; if the student's answer is incorrect, the computer types a hint based on the student's answer and plays the notes on the organ again. All of the questions, musical notes, expected answers, responses and hints are stored on disc in a form suitable for presentation to the student.

Two programs are needed to achieve these capabilities:

one, a teaching program to be used by the student as described above; two, a file building program to be used by the instructor to store the questions and answers for the teaching program. Thus the disc file containing questions is written by the file building program and read by the teaching program. The file building program includes MTRANS, a subroutine which translates musical notes from CHORDAL II notation to an internal form; and both programs include PLAYIT, a subroutine which plays the electronic organ.

Data for CAI in PROJECT CLEF have been organized into strands and substrands, where a strand is a musical subject area such as chords, clefs, modes, scales, tetrachords, trichords, various progressions, species counterpoint. A substrand is a special topic within a strand, such as major chords, major or minor scales, I-IV-V^7-I progressions. A strand consists of one or more substrands; a substrand consists of from one to sixty questions. Each question within a substrand is composed of nodes, of the following six types:

type	number	meaning
I	1 or more	instructions presented once, when the question is first asked
Q	1 or more	word text (optional) followed by music test (optional), presented each time the student is prompted for an answer.
R	1 or more	text of a right answer, followed by the computer's reply to the student
W	0 or more	text of a wrong answer, followed by the computer's hint to the student
S	1	computer's response if the student's answer was not found among R and W nodes
G	1	computer's response if the student's answer was not found among the R and W nodes and response S has already been typed three time

PROJECT CLEF, contd.

The disc file has a directory, containing the name of each strand and the names and locations of its substrands, and for each substrand a question table, containing the location of each question.

The file building program prompts the instructor for strand and substrand names, comparing them with those in the directory and giving the instructor a chance to correct them if a name has been misspelled. Then it accepts question nodes for a substrand. Each musical selection entered in a node of type Q is decoded and played on the electronic organ, so the instructor can change it if the result is not as expected. The questions are written on the disc file, and at the end of the session the directory is updated.

The teaching program prompts the student for strand and substrand names, then randomly chooses questions from the substrand selected. (See Fig. 3). The student can go on to another substrand after answering all of the questions or any multiple of ten questions. The session terminates when no new substrand or strand is selected.

Conclusions

The recent phases of PROJECT CLEF demonstrate the feasibility and practicality of implementing, on a dedicated, locally-based, stand-alone minicomputer system, pedagogical strategies which are typically associated with much larger systems. Among the advantages are: availability of the system for maximum hands-on experiences of different types for faculty and students; costs which are substantially less than those of a large system; capability of continuous software revision and update. The disadvantages of small systems must not be overlooked, however, especially in reference to limited memory and time-sharing capabilities. Use of upward compatible systems may reduce, but not eliminate, these problems.

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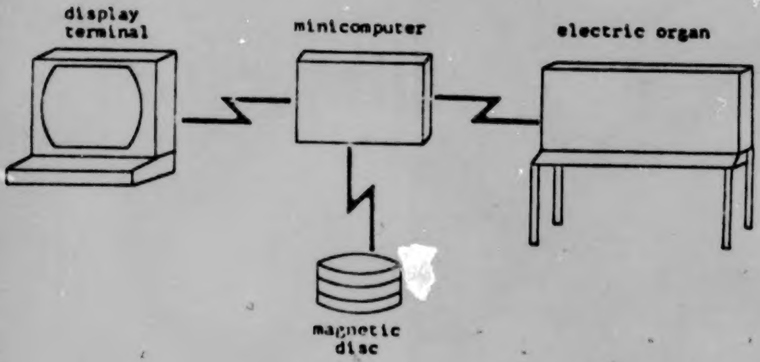
display terminal
minicomputer
electric organ
magnetic disc

Figure 1. Minicomputer System for CAI in Music

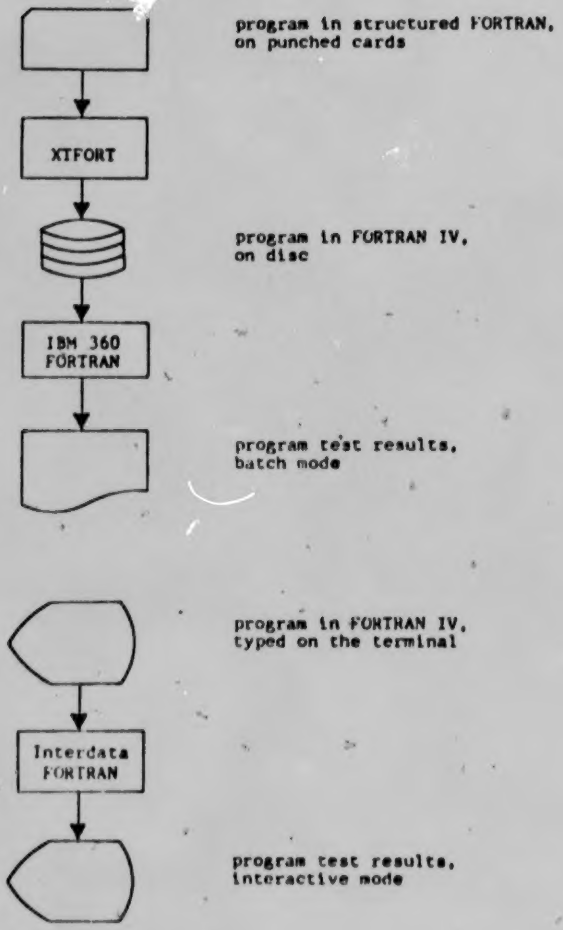
program in structured FORTRAN,
on punched cards
XTFORT
program in FORTRAN IV,
on disc
IBM 360
FORTRAN
program test results,
batch mode
program in FORTRAN IV,
typed on the terminal
Interdata
FORTRAN
program test results,
interactive mode

Figure 2. Program Implementation

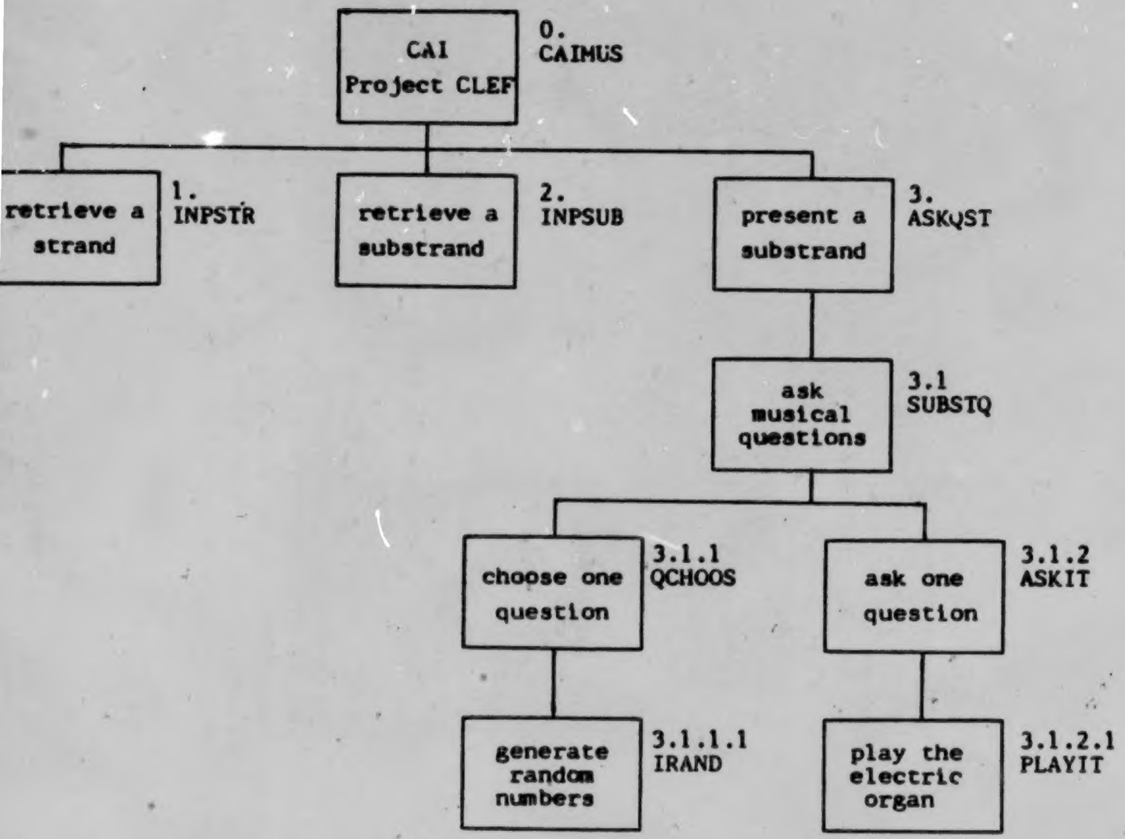
CAI
Project CLEF
0.
CAIMUS
retrieve a
strand
1.
INPSTR
retrieve a
substrand
2.
INPSUB
present a
substrand
3.
ASKQST
ask
musical
questions
3.1
SUBSTQ
choose one
question
3.1.1
QCHOOS
ask one
question
3.1.2
ASKIT
generate
random
numbers
3.1.1.1
IRAND
play the
electric
organ
3.1.2.1
PLAYIT

Figure 3.
Structure of the Teaching Program

CONTROLLED EVALUATION OF A COMPETENCY-BASED APPROACH TO TEACHING AURAL INTERVAL IDENTIFICATION*

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ABSTRACT

During the 1977-78 academic year, twenty-four music majors at the University of Delaware participated in a controlled experiment of a competency-based approach to teaching aural interval identification. All of the students were taught ascending intervals using a traditional learning sequence from the Benward ear-training series. Twelve of the students continued to learn descending, mixed ascending and descending, and harmonic intervals by the same methods in a sequential control group. The other twelve learned in a competency-based experimental group. Results of achievement tests show that whereas there was no significant difference in the amount of learning between the two groups on the basis of ascending intervals, the competency-based experimental group learned significantly more on subsequent materials than did the sequential control group. An analysis of student learning styles shows that whereas students in both groups spent the same amount of time learning, the competency-based format caused students in the experimental group to spend a greater proportion of their time on the more difficult materials than did students in the control group. Results of an attitudinal survey show that students in the experimental group were unaware of the beneficial effects which the competency-based approach was having on their achievement scores. They felt that having to meet the competencies made them do needless extra practice which they would have otherwise omitted.

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INTRODUCTION

During the past four years a computer-based ear-training program called GUIDO has been developed through the University of Delaware's PLATO Project. The initial design and evaluation of the program is described in the Journal of Computer-Based Instruction (Hofstetter, 1975). The GUIDO system includes programs which teach the aural identification of intervals, melodies, chord qualities, harmonies, and rhythms. The original design of the system followed a sequential format. The programs read questions from a predetermined list which had been typed into the computer by the instructor. The students had to go through all of the questions in the same order. There were no provisions for automatically branching them ahead to more difficult materials if a given unit of instruction was too easy for them, nor for giving them additional practice if a unit was too difficult. It was also difficult for the instructor to change the materials being presented by the computer. If he wanted to change the questions being asked, he had to type new lists for the program to read. If he wanted to change the way in which questions were asked, he had to redesign the computer program; such changes are very time consuming.

In an attempt to make the programs easier for instructors to use, and also in order to take advantage of the ability of the computer to keep track of how well students are doing and to adjust the level of difficulty according to individual differences, the GUIDO programs are being redesigned according to a competency-based, table-driven format. During the summer of 1977, the redesign of the intervals program was completed. In order to compare the effects of delivering instruction in aural skills by the sequential method of the original GUIDO design and the competency-based method of the new table-driven competency-based program design, a controlled experiment was conducted during the 1977-78 academic year. The experiment measured not only achievement, but also learning styles and student attitudes.

PROCEDURES

Twenty-four freshman music majors participated in the experiment during their first-year ear-training course. During the first semester, all of the students received the same course of instruction in ear-training with two hours per week of class time devoted to sight-singing, rhythmic training and conceptual development, and two hours per week spent practicing dictation exercises with the GUIDO system. During the first semester the students learned how to identify ascending melodic intervals. The textbook used was Bruce Benward's Workbook in Ear-Training (1969). Seven GUIDO units were assigned to the students, corresponding to the first seven units of intervals in the Benward series. Table 1 shows the titles and corresponding Benward chapter numbers for the seven GUIDO units. Each unit consisted of fifty intervals. Students were permitted to go back and review previous materials as they wished.

Table 1

Titles and Corresponding Benward Chapter Numbers for the Seven GUIDO Units

Chapter Number	Title
1-D	Intervals of the P 8, P 4, M 7, M 2
2-D	Intervals of the m 2, M 3, Tritone (T), M 6
3-D	Intervals of the m 3, P 5, m 6, m 7
4-D	Intervals of the m 2, M 2, M 3, P 4, M 7, P 8
5-D	Intervals of the m 3, Tritone (T), P 5, m 6, M 6, m 7
6-D	Intervals of the m 6, M 6, m 7, M 7
7-D	All Intervals

At the end of the first semester, all twenty-four students were given an achievement test which consisted of four sub-tests covering ascending, descending, mixed ascending and descending, and harmonic intervals, respectively. Each sub-test consisted of twenty-six intervals, with two occurrences of each of the thirteen simple intervals. The scores from the first sub-test were used to rank the students on the basis of achievement from 1 (highest) to 24 (lowest). The odd-numbered students were assigned to a control group which continued learning intervals by the same sequential methods during the second semester. The even-numbered students were assigned to an experimental group which learned intervals according to the competency-based approach during the second semester. The sub-test scores for descending intervals, mixed ascending and descending intervals, and harmonic intervals were used as pre-tests in order to assess the abilities of both groups to hear the new materials prior to their introduction in class. Table 2 shows the results of the four sub-tests. A t-test applied to the scores from each of the sub-tests showed that there were no significant differences between the control and the experimental groups on the basis of any of the four sub-tests.

Table 2

Pre-Test Scores for Students in the Sequential Control Group and in the Competency-Based Experimental Group on the Basis of Ascending, Descending, Mixed Ascending and Descending, and Harmonic Intervals.

Student Groups (N=24)	Sub-Test Scores By Interval Types											
	Ascending			Descending			Mixed Ascending and Descending			Harmonic		
	Mean	Standard Deviation	t	Mean	Standard Deviation	t	Mean	Standard Deviation	t	Mean	Standard Deviation	t
Sequential Control Group (N=12)	84	16.8	N.S.	74	17.8	N.S.	78	15.9	N.S.	63	17.5	N.S.
Competency-Based Experimental Group (N=12)	85	13.0		74	12.1		79	10.3		67	10.6	

The application of sequential and competency-based treatments to the two student groups during the second semester was greatly facilitated by the new table-driven design of the GUIDO system. In the table-driven design the intervals program is controlled by a master table. Table 3 shows the table used during the second semester. By studying this table the usefulness of the table-driven program can be readily seen. In column 1 the instructor numbers each one of the eight interval units. In column 2 the instructor gives the titles which are shown to students when they enter the units. The titles given in Table 3 show how descending intervals are taught first in three progressively more difficult units (after Benward), then all intervals are mixed together in both ascending and descending modes of presentation, and then harmonic intervals are presented in much the same way as descending intervals (again after Benward).

In column 3 the instructor tells the computer how the intervals are to be played, either as melodic ascending (A), descending (D), mixed ascending and descending (M), or as harmonic (H). In column 4 the instructor specifies the number of seconds the intervals are to be played. In columns 5-17 the instructor marks with an "X" those intervals which are to be included in each unit. The last three columns are the most important for the present study. In these columns the instructor defines the competencies which students must meet in order to go on to succeeding units. A required response time is specified, along with the number of trials required to be correct, such as 7 out of 8 consecutive trials as specified in the first unit of Table 3.

Table 3

Master Table Showing the Eight Interval Units Used in the Second Half of the Experiment

Unit Number	Title	Mode of Dictation	Length in Seconds	Intervals to be Included													Competency		
				P1	m2	M2	m3	M3	P4	T	P5	m6	M6	m7	M7	P8	Number Right	Number of Consecutive Trials	Response Time in Seconds
1	m2, m3, P4, P5, M7, P8 Descending	D	1.3		X		X		X		X				X	X	11	12	4
2	M2, M3, T, m6, M6, m7 Descending	D	1.3			X		X		X		X	X	X			11	12	4
3	All Intervals Descending	D	1.3	X	X	X	X	X	X	X	X	X	X	X	X	X	23	26	4
4	All Intervals, Up and Down	M	1.3	X	X	X	X	X	X	X	X	X	X	X	X	X	23	26	4
5	m2, m3, P4, P5, M7, P8, Harmonic	H	1.0		X		X		X		X				X	X	11	12	4
6	M2, M3, T, m6, M6, m7, Harmonic	H	1.0			X		X		X		X	X	X			11	12	4
7	m2, M2, m3, M3, m6, M6, m7, M7, Harmonic	H	1.0		X	X	X	X					X	X	X	X	14	16	4
8	All Intervals Harmonic	H	1.0	X	X	X	X	X	X	X	X	X	X	X	X	X	23	26	4

Key: Mode of Dictation
H = Harmonic
D = Melodic Descending
M = Mixed Ascending and Descending

2.8

During the second half of the experiment, both the control and the experimental groups used the same master table, with the exception that for the control group no competency was set; the control group was merely required to do at least fifty intervals in each unit, just as the students in both groups had done during the first semester. For the students in the control group, competencies were set at a ninety percent level with a required response time of four seconds. The number of consecutive trials required in the experimental group always equalled twice the number of intervals included in the units. A pooling system insured that the intervals were asked twice in each student attempt to attain the required competency.

RESULTS

The results of this controlled evaluation of a competency-based approach to teaching aural interval identification are discussed in three sections. First, achievement scores are compared for both control and experimental groups; second, the learning styles of the students in both groups are compared; third, differences in student attitudes are discussed.

1. Achievement. At the end of the second semester, after all of the students had completed the GUIDO interval program, the same test which was administered at the end of the first semester was given again. The results of this test are shown in Table 4. Both groups improved in their achievement on sub-test 1, which covered ascending melodic intervals. Both groups had learned ascending intervals in the same sequential manner during the first semester. Subsequent practice with descending and harmonic intervals led to an increased level of achievement in melodic intervals for both groups. The results of a t-test applied to the scores of both groups showed that there was no significant difference in achievement on the basis of the first sub-test.

Significant differences were found on the basis of the second sub-test (descending intervals) and on the basis of the fourth sub-test (harmonic intervals). The difference in test scores on the third sub-test (descending intervals) was not significant, although with the experimental group scoring 94 percent and the control group scoring 84 percent it can be seen that the general trend in favor of higher achievement scores for the experimental group is maintained.

Table 4

Post-Test Scores for Students in the Sequential Control Group and in the Competency-Based Experimental Group on the Basis of Ascending, Descending, Mixed Ascending and Descending, and Harmonic Intervals.

Student Groups (N = 24)	Sub-Test Scores by Interval Types											
	Ascending			Descending			Mixed Ascending and Descending			Harmonic		
	Mean	Standard Deviation	t	Mean	Standard Deviation	t	Mean	Standard Deviation	t	Mean	Standard Deviation	t
Sequential Control Group (N = 12)	92	9.9	N.S.	83	13.2	p < .05	84	16.9	N.S.	81	15.1	p < .05
Competency-Based Experimental Group (N = 12)	93	6.1		95	8.3		94	6.2		92	6.6	

Table 5 shows the results of a t-test comparison of the pre- and post-test scores for both the experimental and control groups. In the competency-based experimental group, significant differences were found on the basis of the second, third, and fourth post-tests, that is, on all of the new material learned during the second semester. For the sequential control group, siginificant improvement in aural interval identification was found only on the basis of harmonic intervals. Students in both the experimental and in the control groups improved in their abilities to identify all three types of intervals. However, significant learning gains for the control group were found only on the basis of harmonic intervals, whereas significant learning gains were found on the basis of all three interval types for the experimental group.

Table 5

t-test Comparison of Pre- and Post-Test Scores for the Sequential Control Group and the Competency-Based Experimental Group on the Basis of Ascending, Descending, Mixed Ascending and Descending, and Harmonic Intervals.

Student Groups (N = 24)		Sub-Test Scores by Interval Types											
		Ascending			Descending			Mixed Ascending and Descending			Harmonic		
		Mean	Standard Deviation	t	Mean	Standard Deviation	t	Mean	Standard Deviation	t	Mean	Standard Deviation	t
Sequential Control Group (N = 12)	Pre-Test	84	16.8	N.S.	74	17.8	N.S.	78	15.9	N.S.	63	17.5	p < .05
	Post-Test	92	9.9		85	13.2		84	16.9		81	15.1	
Competency-Based Experimental Group (N = 12)	Pre-Test	85	13.0	N.S.	74	12.1	p < .05	79	10.3	p < .05	67	10.6	p < .05
	Post-Test	93	6.1		95	8.2		94	6.2		92	6.6	

2. Learning Styles. Investigation of how the students spent their time in the GUIDO program shows some important differences between the students who used the sequential appraoch and those who used the competency-based approach. Table 6 shows a summary of student learning styles for the two groups. The first half of the table shows data kept for the sequential control group, and the second half shows data for the competency-based experimental group. For each group there are three columns of data. Column 1 shows the number of intervals which the students did in each unit. Column 2 shows what percentage the figures in column 1 are of the total number of intervals done by the students. Column 3 shows the accumulation of percentages from column 2.

Table 6

Summary of Student Learning Styles in the Sequential Control Group and in the Competency-Based Experimental Group

Second Semester GUIDO Units	Sequential Control Group			Competency-Based Experimental Group		
	Number of Intervals	Percentage of Total Time Spent	Cumulative Percentage	Number of Intervals	Percentage of Total Time Spent	Cumulative Percentage
1	963	8%	8%	80	1%	1%
2	480	4%	12%	238	2%	3%
3	844	7%	19%	476	4%	7%
4	1907	16%	35%	836	7%	14%
5	2264	19%	54%	842	7%	21%
6	1536	13%	67%	139	12%	33%
7	1552	13%	80%	2271	19%	52%
8	2362	20%	100%	5723	48%	100%

By comparing the percentages for the two groups it can be seen that the experimental group spent less time in the earlier units and more time in the later units, whereas the control group had a more even spread of percentages among the eight units of instruction. For example, the competency-based experimental group spent only one percent of its time completing unit number one, whereas the sequential control group spent eight percent of its learning time in that unit. The competency-based group spent forty-eight percent of its learning time in the last and most difficult unit, namely, harmonic intervals, whereas the control group spent only twenty percent of its time in that unit.

The average response times for each group were nearly the same. The average response time for the competency-based group was 2.8 seconds per inteval, and the average response time for the sequential control group was 2.9 seconds per interval. Each student in the experimental competency-based group spent an average of forty-six minutes doing interval drills during the second semester. The average time spent by students in the sequential control group was forty-eight minutes. Because the average response times and learning times were nearly the same for the two groups, the differences in achievement scores noted above can be attributed to the effect which the competency-based method had on making sure that the students moved on to more difficult materials when they were ready.

3. Student Attitudes. An analysis of student attitudes revealed that the students in the experimental group were not aware of the beneficial effect which the competency-based approach was having upon their grades. Student attitudes were measured by means of an evaluation instrument which has been developed during the past three years by instructional designers in the University of Delaware PLATO Project. This instrument consists of a series of twenty-three statements with which students are asked to indicate their relative agreement or disagreement, and two essay questions in which they are given an opportunity to write about what they have liked most and what they have liked least about PLATO. This evaluation was administered to the students in both the experimental and in the control groups along with the achievement tests at the end of the first semester as a pre-test and at the end of the second semester as a post-test. Table 7 shows the results.

On the pre-test, prior to the beginning of the competency-based treatment in the experimental group, the students in both groups were in basic agreement on all of the questions. They agreed that PLATO was an enjoyable learning experience, and that the instructional variables were set just right for them. Almost all of the students wanted to take another course which uses PLATO. On the post-test their opinions were very similar to those expressed on the pre-test. However, on the post-test there were two questions in which a marked difference in student responses was found.

In response to questions #8 and #18, the competency-based students expressed opinions which were totally unanticipated. In response to question #8, the competency-based students reported a much higher level of frustration than did the sequential control students. Seventy-five percent of the competency-based students agreed that they were frequently frustrated, whereas only twenty-five percent of the sequential students agreed with that statement. On the essay section of

Table 7

Results of the Student Evaluation of CWIRD Intervals Program Before and After the Application of the Competency-Based Treatment in the Experimental Group; Numbers Given are Percentages of the Students in Each Group Giving the Responses. Boxes have been drawn around percentages where Major Differences Exist on the Basis of the Post-Test. (Δ > 50%)

Questions	Sequential Control Group						Competency-Based Experimental Group					
	Pre-Test			Post-Test			Pre-Test			Post-Test		
	Agree	Neutral	Disagree	Agree	Neutral	Disagree	Agree	Neutral	Disagree	Agree	Neutral	Disagree
1. Using PLATO was an enjoyable learning experience	92	8	0	92	8	0	75	25	0	83	17	0
2. The mechanics of using the PLATO terminal distracted me from learning.	33	8	58	17	8	75	33	33	33	0	42	58
3. The major points of the lesson were made clear.	83	17	0	83	17	0	92	8	0	92	8	0
4. The lessons on PLATO were too advanced for our level.	0	8	92	0	17	83	0	0	100	17	0	83
5. I learned what the lessons tried to teach.	75	25	0	75	8	17	100	0	0	92	8	0
6. I already knew the material covered in the lessons.	8	25	67	17	25	58	25	25	50	0	33	66
7. Most of the time the work on PLATO was too easy for me.	8	33	67	8	33	67	0	33	67	8	25	58
8. I was frequently frustrated while working on PLATO.	33	58	25	8	58	33	33	33	33	75	8	17
9. The lessons progressed too slowly.	17	33	58	0	17	83	8	8	83	17	8	75
10. The PLATO lessons were unnecessarily picky about the form of the correct answer.	0	58	42	17	25	58	0	8	92	8	50	42
11. The pace of the lessons was too fast.	8	8	83	8	50	42	8	17	75	0	33	66
12. PLATO is an efficient use of the student's time.	83	17	0	100	0	0	100	0	0	67	8	25
13. PLATO is well suited to presenting instructional material in this subject.	100	0	0	92	8	0	92	8	8	92	0	8
14. PLATO gives the student more feedback than other forms of instruction do.	67	25	8	67	8	25	58	8	33	50	33	8
15. The PLATO lessons helped me learn the material more thoroughly than with other forms of instruction.	75	17	8	67	25	8	67	17	17	67	17	17
16. The lessons made allowances for students with different levels of understanding.	33	67	0	33	58	8	50	42	8	50	17	33
17. A lesson on PLATO is more interesting than traditional instruction.	83	17	0	75	17	8	67	25	8	67	25	8
18. I found myself just trying to get through the material rather than trying to learn.	0	33	67	0	42	58	17	33	50	66	17	17
19. In view of the effort I put into it, I was satisfied with what I learned while using PLATO.	83	17	0	100	0	0	100	8	0	75	17	8
20. Too much class time was spent using PLATO.	0	33	67	0	33	67	8	8	83	0	17	83
21. I would like to spend more class time using PLATO.	17	67	17	25	67	8	8	67	25	8	50	33
22. I would like to take another course which uses PLATO.	67	33	0	67	25	8	75	25	0	75	8	17
23. I was able to schedule enough time each week in which to work.	75	25	0	83	8	8	75	17	8	67	17	17

the evaluation, the competency-based students indicated that the source of their frustration was in being required to get 23 out of 26 harmonic intervals correct. Related to this was the response to question #18. Sixty-six percent of the competency-based students agreed that they found themselves just trying to get through the material rather than trying to learn, whereas none of the sequential control students had this feeling.

SUMMARY

This controlled evaluation of a competency-based approach to teaching aural interval indentification measured three instructional variables, namely, achievement, learning styles, and student attitudes. Students in the competency-based experimental group achieved significantly higher grades than students in the sequential control group. Comparative analysis of student learning styles showed that the competency-based approach led to a much better use of student time than did the sequential approach. Students in the competency-based group spent less time on the beginning units and more time on the difficult units, whereas student time in the sequential group was more evenly distributed among all of the interval units.

The beneficial effects which the competency-based approach had on achievement and learning style were somewhat offset by attitudes toward the new technique. The required ninety percent competency led to a high level of frustration in the experimental group which was not experienced by students in the sequential control group.

The anomaly is evident. Whereas measures of achievement and learning style show that the competency-based students learned significantly more in the same amount of time as spent by students in the control group, an attitudinal study shows that they have negative feelings toward the approach. The competency-based students felt that the required competencies were not helping them to learn. On the contrary, they considered the competency-based approach to be a frustrating experience in which needless dictation exercises were done just in order to meet the competencies.

The results of this study indicate that the competency-based approach to teaching aural interval identification leads to significantly higher achievement scores than does the sequential approach. However, steps should be taken to reduce the level of student frustration toward this approach before implementing it on a wide scale. Lowering the competency would reduce the level of student frustration, but it would also probably result in lower achievement scores. Since this study was the first controlled evaluation of a competency-based approach to teaching aural skills, students in the competency-based group had no prior knowledge that the new experimental approach was going to help them. If the results of this study were made available to them prior to the beginning of aural training, they might realize that even though the competency-based approach may seem like it is wasting their time, it really is leading them to a higher level of mastery than more conventional sequential techniques.

Another way of reducing the level of student frustration may be to change the manner in which the competency tests are administered. In the approach used in this study the computer constantly kept score for the students and branched them ahead when they met the competencies; the students were always being tested, whether they felt they were ready for a test or not. A less frustrating approach may be to let the students practice the interval units in a non-competency-based drill-and-practice format, and allow them to request a test when they think they are ready to take it. The continuation of this study will attempt to measure the combined attitudinal effects of making students aware of the achievement data in this article as well as of including non-graded drill units in the competency-based delivery system.

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COMPUTER-BASED EAR-TRAINING INSTRUCTION FOR NON-MUSIC MAJORS

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ABSTRACT

During the Spring Semester of the 1978 academic year, fifty-two students enrolled in a beginning music theory course for non-music majors participated in a study designed to examine the success of a competency-based approach for teaching aural interval identification to non-music majors. During the same time period a parallel study was being undertaken to measure the success of a competency-based format for teaching interval identification to music majors (Hofstetter, 1978). Both studies utilized the Interval Dictation Units of the GUIDO program at the University of Delaware. A comparison of data obtained from the two studies was helpful in identifying problems unique to non-majors in their acquisition of aural-perceptual skills.

In both studies the students proceeded through GUIDO interval units covering ascending intervals. Then they received a pretest which tested their skill at identifying ascending, descending, and harmonic intervals. Half of the students were assigned to an experimental group and proceeded through the interval units covering descending intervals, a mixture of ascending and descending intervals, and harmonic intervals following a competency-based format. The other half of the students became the control group and proceeded through the same interval units following a sequential non-competency based format.

Results of the study involving the music majors revealed that the competency-based approach was superior to the sequential approach for teaching interval dictation skills. However, results of the study involving the non-majors indicated that the two methods of instruction were not significantly different in helping the non-majors develop the interval aural-perceptual skills. Other data kept by the PLATO system revealed

that among the twenty-seven students in the experimental group, only one student finished all the interval units required for the course. On the other hand, fifteen out of twenty-five students in the control group finished all the units required.

Recommendations for changing the ear-training lessons in the GUIDO program for non-majors are as follows:

(1) The drills should remain in the sequential format. The students should be given mastery tests which will determine the difficulty level of materials to be covered.

(2) Help units should be included on the PLATO system to provide students with techniques for listening.

(3) More elementary units within each of the ear-training lessons should be included to give students practice developing simple ear skills as preparation for the drill materials presently on the system.

INTRODUCTION

The computer-based ear-training program called GUIDO has been in existence at the University of Delaware on the PLATO system for four years now. The GUIDO music lessons were designed to be used in conjunction with the beginning ear-training courses taken by music majors in the Department of Music. During the 1977-78 school year, students enrolled in a beginning theory course for non-majors were required for the first time to spend time at the PLATO terminals practicing drill materials from the GUIDO lessons.

Most of the music majors at the University of Delaware have some proficiency on an instrument. Some of these students are composers. In order that the majors may develop the complex musicianship skills necessary for them to function adequately in their musical careers, they must receive a great deal of training in the aural-perceptual skills as well as in the written skills. On the other hand, students enrolled in the beginning theory course for non-majors are a diverse group. Most of these students have a minimal knowledge of music. Some of them are performers, but a great number of them have never performed on an instrument or regard performance as secondary to other non-musical career goals. The purpose of the beginning course for non-majors, then, is to help these students develop basic written skills and gain basic information useful for helping them understand music in their everyday lives. Since sound is the medium for the art of music, these students receive aural-perceptual training so that they may better understand the basic written skills and other information that they learn in the music theory course. Thus ear-training is only a small component of the non-major course.

The learning of even the most basic aural-perceptual skills requires a great deal of drill. In the ear-training courses for majors, such time is difficult to find in the classroom because the teacher must spend most of the available class time in sight-singing and in teaching students proper techniques for listening. In the non-major course, where so much of the class time is spent by the student learning written skills, drill work in class is virtually impossible. In the case of both the majors and non-majors the drill must occur outside of the classroom. The GUIDO ear-training exercises provide an excellent opportunity for both music majors and non-music majors to practice improving their aural skills.

Students enrolled in the beginning course for non-majors are presently required to proceed through interval drills and the beginning units of the melody, rhythm, and chord quality drills. Students enrolled in the ear-training course for majors are presently required to do advanced units in each of the drill areas required of the non-majors as well as units in the area of harmonic dictation. Table 1 shows the number of units required of the majors and the non-majors in each of the skill areas.

Table 1

GUIDO Units Required of The Students Enrolled in The Beginning Ear-Training Courses for Music Majors and The Beginning Course for Non-Majors

Student Groups	GUIDO Lessons Required				
	Intervals	Melody	Rhythm	Chord Quality	Harmony
Majors	14	21	23	22	20
Non-Majors	14	8	8	6	0

During the 1977-78 school year, both music majors and non-majors took part in a study designed to assess the success of a competency-based approach as opposed to a sequential non-competency-based approach in drilling ear skills by GUIDO. The Interval Dictation Drills available among the GUIDO lessons were the only ones that the students in the non-major course were required to finish. Since the music majors were also required to complete these same interval units and since both a competency-based and a non-competency-based version of the same interval materials exists within the GUIDO lessons, a comparison of the competency-based and non-competency-based instructional methods could be made using the Interval Dictation Drills.

PROCEDURES

Fifty-two students enrolled in the beginning course for non-majors participated in an experiment to test two different methods of ear-training instruction on the PLATO system. The students were required to spend a minimum of one hour per week on the PLATO system engaged in the GUIDO lessons. Table 2 shows the index for the Interval Dictation Units. This grouping of intervals in each unit follows the grouping of Benward in his Workbook in Ear-Training (Benward, 1969).

Table 2

Interval Dictation Units in The GUIDO Program

Unit Number	Grouping of Intervals Within Each Unit
1	Intervals of the P1, M2, P4, M7, Ascending
2	Intervals of the m2, M3, Tt, M6, Ascending
3	Intervals of the m3, P5, m6, m7, Ascending
4	Intervals of the m2, m3, P4, P5, M7, P8, Ascending
5	Intervals of the M2, M3, Tt, m6, M6, m7, Ascending
6	All Intervals, Ascending
7	Intervals of the m2, m3, P4, P5, M7, P8, Descending
8	Intervals of the M2, M3, Tt, m6, M6, m7, Descending
9	All Intervals, Descending
10	All Intervals, Ascending and Descending
11	Intervals of the m2, m3, P4, P5, M7, P8, Harmonic
12	Intervals of the M2, M3, Tt, m6, M6, m7, Harmonic
13	Intervals of the m2, M2, m3, M3, m6, M6, m7, M7, Harmonic
14	All Intervals, Harmonic

As can be seen from the table, the units are divided into three major groups: Ascending, Descending, and Harmonic. The decision to start the drills with ascending intervals first, followed by descending intervals, followed by harmonic intervals is based on research in the area of interval perception (Spohn & Poland, 1963) concerning the difficulty of each of the types of intervals. Thus students in both the first ear-training course for majors and the beginning course for non-majors were instructed to proceed through the first six units of interval dictation first. Students enrolled in the first ear-training course for majors were required to do only the first six interval dictation units. These units were non-competency based. In other words, the students could proceed through the drills at their own pace. No limit was placed on the number of items that could be missed. The students were instructed to drill on each unit until they had finished the fifty items available for each unit. At the beginning of the second semester course they were given a pretest covering all fourteen interval units. The pretest consisted of four sections testing ascending intervals, descending intervals, a mixture of ascending and descending intervals, and harmonic intervals. Each section consisted of twenty-six items. Then they were divided into two groups. The control group went through each of the remaining eight units using the sequential non-competency-based format. The experimental group went through the same interval units which were organized in a competency-based format, where a time-limit of four seconds was placed on each student for responding and where the students had to achieve a competency of 90% for each unit. At the end of the semester, the students received a posttest identical to the pretest (Hofstetter, 1978). In order that comparisons between the students enrolled in the course for majors and students enrolled in the course for non-majors could be made, students enrolled in the non-major course were instructed to proceed through Units One through Six only. Then they were given the same pretest that the music majors received. Then the non-majors were instructed to work through Units Seven through Fourteen. They were given the identical posttest at the end of the semester.

RESULTS

Table 3 shows the results of a t-test comparison of experimental and control non-major groups for the pretest.

Table 3

Pretest Scores for Students in the Sequential Control and Competency-Based Experimental Non-Major Groups on the Basis of Ascending, Descending, Mixed Ascending and Descending, and Harmonic Intervals.

Interval Type	Sequential Control Group (N = 25)		t test	Competency-Based Experimental Group (N = 27)	
	Mean	Standard Deviation	t	Mean	Standard Deviation
Ascending	67	20.3	N.S.	66	21.9
Descending	54	21.9	N.S.	59	19.7
Mixed Ascending & Descending	59	18.8	N.S.	58	23.2
Harmonic	45	21.5	N.S.	42	18.5

Table 4 shows the results of a t-test comparison of experimental and control non-major groups for the posttest.

Table 4

Posttest Scores for Students in the Sequential Control and Competency-Based Experimental Non-Major Groups on the Basis of Ascending, Descending, Mixed Ascending and Descending, and Harmonic Intervals.

Interval Type	Sequential Control Group (N = 25)		t test	Competency-Based Experimental Group(N = 27)	
	Mean	Standard Deviation	t	Mean	Standard Deviation
Ascending	76	21.2	N.S.	77	20.6
Descending	67	25.0	N.S.	68	18.8
Mixed Ascending & Descending	69	21.0	N.S.	71	20.6
Harmonic	57	25.0	N.S.	56	18.0

As can be seen from Tables 3 and 4, there was no significant difference between experimental and control groups on the pretest or posttest. Therefore it appears that for these non-major students, the different instructional formats did not make any difference in aural-perceptual skill development. These finds differ from those of Hofstetter (1978) where students in the experimental music major group scored significantly higher on the descending interval and harmonic interval portions of the posttest, than did students in the control music major group.

DISCUSSION

One could make the argument that to compare music majors with non-majors is the equivalent of comparing apples with oranges. In a sense this is true. One would expect from the outset that the majors would have better scores than the non-majors on the same pretest and posttest. However, one should expect that if the competency-based drill procedure were appropriate for the non-majors, that the experimental group should have performed significantly better than the control group on the posttest.

Data kept by the PLATO system revealed that among the twenty-seven students in the experimental non-major group, only one student finished all the interval units required for the course. Among the non-majors in the control group, fifteen out of twenty-five students finished all the units required. Perhaps there was something about the competency-based treatment that produced great problems for the non-major students in the experimental group.

The criterion level for majors and non-majors alike was 90% with a required response time of four seconds per item. Although this competency level is high, discussions with non-major students suggest that at least part of the problem lies in the manner in which the competencies were achieved. As students went through the competency-based drills, they received constant updates on their scores in each unit as they proceeded through each item of each unit. The students were required to achieve the 90% competency within a pre-determined number of consecutive trials. For example in Unit 7, the students were required to answer eleven correct in twelve consecutive trials. A student who, for example, answered seven correctly in that unit but who answered eight and nine incorrectly, watched his score go from seven to zero. He then had to start over again. Furthermore, the four-second criterion for responding was not average competency time, but a maximum for each item. If the student did not respond within four seconds to an item, he was told that his time had elapsed. Such procedures are not likely to insure feelings of self-confidence even in the best of students. However, the music majors who entered the program with substantially higher ability levels than the non-majors also most likely entered with higher levels of self-confidence. They were probably more likely to continue working after having failed once or twice than were the non-majors. It is no wonder then that many of the students in the non-major experimental group gave up, especially after attempting three of the interval units where they were expected to answer twenty-three items correctly in twenty-six consecutive trials.

Of course reducing the criterion level would have helped insure success for the non-majors. However, perhaps a better course of action would have been to change the procedure by which competency was attained. One possible change would be to require each student to take mastery tests on ascending, descending, and harmonic intervals. The student would be told his score after he finished the test containing a finite number of items. If he did not achieve mastery, he would then be given non-competency-based drills on intervals. He would have the option of proceeding through the drills until he felt confident that he could pass the mastery test. Thus the student would feel as though he had some control over the entire process. Although tests invariably produce some anxiety in students, the anxiety resulting from a mastery test would probably be far less than that resulting from competency-based drills.

An adequate procedure for producing competency-based ear-training materials is one way to insure that students, both majors and non-majors, learn the materials. However, there are a variety of other procedures that can be taken to help the non-major specifically. These same procedures may be of help to the music major having great difficulties with ear-training.

One procedure is to provide instructional help units within the drill package that students can refer to when necessary. The help units could be short but provide techniques for listening. Another procedure is the provision of very small exercises to precede existing exercises. For example, within the melody units, small three-to-four tone groups could provide students with practice in hearing the tonal center without the necessity of also grappling with the memory span necessary for a long string of tones. Similarly, drill on small rhythmic patterns could provide a good introduction to rhythmic dictation. Even though harmonic dictation has not been an integral part of the ear-training drill materials for non-majors at the University of Delaware, the provision of short chordal progressions within the context of jazz and popular songs, where the students would be asked to provide lead sheet symbols and aural formal analyses of the tunes, would provide the student with practice in ear-training very appropriate to his needs. These and other procedures are now being developed to be included in the GUIDO lessons.

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SEX EDUCATION ON PLATO

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ABSTRACT: Medical students, housestaff, and practitioners, as well as a general Plato user population were given an opportunity to learn about counseling obstetric and gynecologic patients through a Plato lesson called "Introduction to the Role of the Obstetrician-Gynecologist as a Sex Educator." This paper discusses the rationale for the lesson, user reactions to it, and the statistical evaluation of the user data required. A special section highlights user contributions to the lesson through the attached notefile, "Sexednotes." Some sample questions are included, as is a discussion of the problems of constructing and maintaining a lesson of this type. In general, the lesson has been well received by users and has fulfilled its function as a supplement to the regular curriculum.

INTRODUCTION

Sex is an integral part of our lives, a source of a little worry, much fantasy, and a tremendous amount of mythology. It is used to sell deodorant, cigarettes, and sodapop; it is a basic physiological activity essential for life.

Unfortunately, however, sex is almost completely ignored in most curricula, despite the recommendations of numerous study groups for its inclusion. Primary social problems such as unwed motherhood, veneral disease, and child abuse continue to cause wringing of hands and political controversy while being ignored by teachers in class. Even among medical students preparing for gynecologic or obstetric practice there is little discussion of sexual practice, and virtually nothing about counseling and educating patients.

Scully and Bart (1973) studied 27 gynecological textbooks and found only four which indexed orgasm. Three of the four texts said vaginal orgasm was characteristic of mature women, a fact which Masters and Johnson (1966) and other sex researchers dispute vehemently and dismiss as pure myth. Because most gynecological texts are not up-to-date regarding human sexuality, most obstetricians and gynecologists lack the knowledge and skills to be effective sex educators and counselors. One way to alleviate this deficiency might be to use interactive computer assisted instruction to deal with issues of sex counseling. Accordingly, we constructed a Plato lesson called "Introduction to the Role of the Obstetrician-Gynecologist as a Sex Educator" (file name: sexed) to test the feasability and acceptability to the student of using CAI for learning about sex counseling. The lesson is aimed at medical students preparing to specialize in obstetrics and gynecology, but is open to all students and readily available on the Plato Health Science Network catalog.

METHOD

We chose Plato because it allows for discussion and interpersonal interaction while retaining anonymity and privacy through the easily used and accessed notes files. In addition, the Plato Health Science Network serves a variety of medical schools so that the lesson could receive widespread use by the target groups. Finally, we could keep statistics on lesson usage and determine the amount of learning achieved by users through the inclusion of a pretest and posttest in the lesson iteself.

The lesson unfolds as follows: first, the student sees a brief explanation of the pretest, followed by the ten question true/false pretest itself. Next, the index of the lesson is presented, consisting of six sections with didactic material and three additional sections: bibliography, statistics, notefile. The student types the number of the section he wishes to study.

When all six didactic sections have been completed, or when the student leaves the lesson (by pressing SHIFT-DATA to return to the Plato Health Science Network catalog), he is automatically routed first to the posttest. The posttest is explained in a brief display, and he is given the option to skip it or assist in the evaluation of the lesson by taking it. The same ten questions presented in the pretest are then shown to him again. Since the pretest and posttest consist of 10 items randomly selected from a pool of 25 items at each presentation, at the conclusion of the ten question posttest, as an added check on learning we give the student the option of answering the additional 15 test items just to see if his performance on all test questions is better than on the pretest.

The questions on the pretest are constructed to cover problems often brought up by patients with sexual dysfunction, pregnant patients, or patients seeking information on topics about which much misinformation is commonly available. All points covered in the pretest are also dealt with in the lesson. Below are some sample questions from the pretest:

> "With pregnancy, it is best to discontinue intercourse six weeks before the date of confinement, and not to resume intercourse until six weeks after delivery." (answer: false).
>
> "Women have weaker sex drives than men." (false)
>
> "Episiotomy is essential in most, if not all, deliveries." (false)

Of the twenty-five questions, twelve are false and thirteen are true. Thus, the average score expected by chance would be about 50% correct.

A typical didactic section begins with a one or two page introductory statement, followed by 10 to 20 frames consisting of interactive questions, based on the Skinnerian model of "shaping" or one-trial learning. This type of format requires a great deal of review and revision in order to achieve criterion, and toward that end we incorporated in the lesson a statistic for each item which states how many people attempted to answer it and how many correctly answered on the first try. Thus the student in going through the lesson has an idea of how he is progressing in comparison to all the others who have tried the lesson, and we as authors have an index of problem frames that need revision.

Ideally, each question should be answered correctly on the first try by 90% of students attempting it. Thus the student learns through positive reinforcement of correct responses, with each new bit of knowledge built on that which he has already learned (Holland and Skinner, 1961). In fact, few of our questions are answered correctly by 90% or better of the subjects. However, in many ways the lesson is more of an attitude survey or stereotype buster than it is straight didactic programmed learning. Not only do many students assume they are already experts on the subject matter, but there is also a heavy load of cultural norms, assumptions, and sanctions working to support various "truths" about sexual practice which may be mutually contradictory but entirely valid according to previous learning of various students (Berger and Luckman, 1966). Thus any attempt to achieve a criterion of 90% on these types of questions is doomed to failure without a preselected culturally homogeneous sample. In a cafeteria-style catalog on an international computer network such a preselection is impossible to achieve, even if it would be deemed desirable.

The six didactic sections of the lesson are as follows:

1. Introduction
2. Physician attitude
3. Sex history as a part of the medical history
4. Sex education as a part of the routine pelvic exam
5. Sexual relations during pregnancy and postpartum
6. Common sexual dysfunction

Each section deals with common problem areas repeatedly brought to the attention of two of the authors in their roles as sex therapists.

To assess the likelihood of students actually writing comments and acting to modify the content of the lesson, we added to each page a reminder that comments were welcome and directions on pressing SHIFT-LAB to write a comment. In one frame in particular, dealing with colloquial names given to oral sex practices, we asked the student to list synonyms he or she knew for "cunnilingus" and "fellatio". As a self-check for the student, we presented as complete a list as we were able to compile of these colloquial terms. We requested the student to send us in a comment any synonyms not on our list but included in the student's list.

This particular frame is probably among the most risque frames in the history of computer assisted instruction. However, we reasoned that in it we had a powerful stimulus situation with which to test the interest of students in sharing their knowledge with their instructor. Since the tone of the lesson is quite serious, even though the subject matter of this question is oral sex, we reasoned that the situation would be a non-threatening one.

RESULTS

The outcomes of the project will be discussed in four parts: volume of usage, evidence of learning, participation by students, and social psychological implications of the lesson. Slides of lesson displays will be utilized to present the graphic data. It is important to note at this point that this lesson is used primarily through the Plato Health Science Network catalog, and that no medical students or others in the target population are assigned the lesson as a part of their regular class work. The lesson is designed purely as a supplement to the regular curriculum.

1. Volume of usage in the first six weeks was the highest it has been for any lesson we have put on the catalog: 485 students entered the lesson; 312 (64.3%) completed the pretest; 109 (23.6%) completed the entire lesson including the posttest.

After this six week period, we completed extensive revisions in the lesson and zeroed our statistics. In the five months following these revisions, 1000 students have entered the lesson, 667 (66.7%) have completed the pretest, and 236 (23.6%) have completed the posttest (see Table 1). A number of interesting conclusions can be drawn from these data.

First, the contrast between the heavy use in the initial six weeks and the lighter use in the subsequent five months should be explained. The most prominent reason for this drop is the fact that the second period is from May to November: final exams and summer vacation. Fewer users were on Plato, and with the coming of autumn and the new year, many experienced Plato users left school, and the new students have not found and explored the catalog yet to see what is available.

A less prominent reason for this drop is found in the size of the Plato subculture of regular users. Experienced instructional designers, programmers, evaluators, and teachers read new lesson notices published in files such as "Reviews" and often try new lessons both for their own interest and to offer critical comments to their author colleagues. When the lesson deals with sex, the urge to try the lesson is naturally very high. Thus, it is quite probable that a large percentage of the Plato authors who heard about the introduction of this new lesson and were conversant enough with Plato to know how to access it did try out. After six weeks the novelty of the lesson had worn down among the floating subculture of Plato regulars and the population of users became predominently students using the medical router.

Second, the difference in figures for entry, pretest, posttest, and individual section completion are of interest. Some students just do not like to take tests and leave. Many others, however, especially those with only student signons, take the pretest because it is the only way they can get access to the notefile Sexednotes. Thus we find large numbers of pretest completers who do not complete the posttest, simply because they only went in to read the notefile.

We rectified this source of misleading data in November, 1978, at the time of writing this paper by adding an index before the pretest giving the student the option of choosing the notefile. Thus the student may follow up his notes with a minimum of extraneous effort and is motivated to return to the lesson by the promise of increased knowledge through the notefile.

2. Learning was evidenced by an increase in the means of the posttest scores over the pretest scores. The mean score of the 312 completers of the pretest during the initial evaluation period was 80%. The 99 students who completed the posttest scored an average of 90%. After students finished the 10 item pretest they were given the option to continue on and complete the entire 25 items. Sixty-nine students did complete the 25 item test, and they scored an average of 93%. Thus it can be seen that the experience of studying the lessons raised the mean score over 10%, even for questions not previously asked.

These findings were repeated in the subsequent five month period after the reinitialization of the statistics. The mean score of the 667 completers of the pretest was 70%. The 236 students who completed the posttest scored 90%, and scored 80% on the pretest. The 112 students who completed the 25 item posttest averaged 90%.

Table II provides some information on each of the sections of the lesson, including times begun, times finished, average time spent in the lesson, and average scores. From these figures it can be seen that we suffered substantial attrition of total users as the sequential user proceeded through each section. Students may have run out of time, they may have lost interest in the subject matter, or they may have found the structure of the lesson threatening to their psychic defenses or unsatisfactory in some other way. Early in the trial run, before the first main revision, one comment was: "This is so silly I can't go on." Others may have felt the same way but left without stating their feelings.

Also evident from Table II is the fact that average scores for each section were much less than perfect, with the sum of the average scores being 43.5 out of a possible score of 66. It should be noted that 14 of these 66 items are essay questions, with the item being scored as "correct" if the student presses SHIFT-NEXT to see the recommended answer to the essay. We made no attempt to have Plato judge the essays: the student merely compared his answer to the one provided by the authors.

Table III contains some figures from the item analysis. Altogether there are 52 frames in the lesson with computer-scored answers. Ideally, according to the "shaping" strategy of programmed learning, 90% of the students attempting a question should be able to answer it correctly on the first try if the question is constructed correctly and builds on a proper foundation of previously laid knowledge. Our questions ranged from 20% to 99% being answered on the first attempt, with the median item being answered by 69.5% of students. This means that more revision of our items is needed -- some are too difficult, and some are too easy. Only nine items fail to be answered correctly by 50% of the students, and these are usually multiple answer items or "natural language" items which take a lot of revision to be correctly stated with the range of answers adequately anticipated. We sometimes get complaints and suggestions from users that these items are unfair. We are correcting these problems.

This difficulty can be illustrated by examining the three items ranked "most difficult" by the item analyses. None is a "trick" question: all are straight-forward inquiries. But the lesson has not prepared the student to know the answers. The most difficult item is a simple true and false question that contains an undefined word:

> Lubrication should be recommended to the patient who presents with vaginismus. (false)

Even if students did know the meaning of vaginismus, they might be tempted to incorrectly answer true; however, most users do not seem to know the meaning of the word -- they may think it is a disease, a malformation, or a psychiatric symptom. In fact, it may be all of these: its meaning is "muscle spasm" and the recommended treatment is use of a graduated sequence of vaginal dilators to slowly loosen the muscles. To improve performance on the item, vaginismus could be the question along with a discussion of treatments. However, an argument could be made for leaving the item as it stands, since by getting it wrong the student is jarred into attending to the fact being taught. Of 164 attempts to answer this item, 20% were correct on the first try.

The second most missed item (23% correct of 155 attempts) is not a problem of lack of information. It is a synthesis question that aims at the student's application of material previously discussed:

> In response to a patient's fear of injury to the fetus through intercourse at any point during normal pregnancy, the physician could appropriately and in the patient's best interest reply with which of the following? Choose all that apply and press NEXT.
>
> a. "Yes", the fetus could be injured. It is best to abstain."
>
> b. "There is no evidence to support or suggest intercourse will harm the baby."
>
> c. "Most evidence now available indicates that with a normal pregnancy, intercourse is perfectly safe until labor starts."

Even though previous frames stressed that no findings indicate that intercourse during pregnancy has any relation to inducing labor or causing other problems, most students still did not infer the correct answers to this item: b and c.

The third most missed question (23% correct of 177 attempts) concerns the age that peak female sex drive is reached. The following choices were given, and the total numbers of responses are shown:

age	number responding
15	8
20	30
25	53
30	136
40	177
50	8

The responses shown are the total attempts made to answer the question. Since everybody who completed the question had to type in the correct answer, age 40 has the total of 177. Age 30 has the total of 136, indicating that 136 of those attempting to answer, or 76.8% of respondants, chose that figure before choosing the correct answer. Thus this frame serves as a gauge of common belief about the role of sexual drive in female aging, an important fact for prospective counselors to know and to communicate to their patients.

3. Participation by students in the issues raised by the lesson is evidenced by notes written in the notefile, called "Sexednotes". Such topics as common and uncommon positions, home birth, personal experience with gynecologists, and questions of infection and morals were posited and discussed by the users and by the lesson authors. A number of respondants thanked the authors for writing the lesson and some criticized what they regarded as the radical or conservative moral tone of the lesson.

In the five month period in which 1000 students entered the lesson, 74 students wrote 118 comments through comment mode, for an average of 1.6 comments per participating student. Unfortunately, many of those comments were never received by the authors, since comments by Plato user type "student" go to group-connected comment files and they were not forwarded to us by the directors of the various groups. Evidently the group directors misinterpreted such comments as "Enjoyed your lesson. You forgot to mention muff-driving and eating at the Y."

Plato user type "author" comments were sent to Sexednotes, and are available for analysis. In addition, Sexednotes is accessible through the lesson index and hence received a lot of use. Unfortunately, we neglected to log the number of jumpouts to Sexednotes from lesson "Sexed". (This oversight was corrected in November, 1978, at the time of writing this paper.)

Notes are classified and tabulated in Table IV, based on 221 notes currently in the file and on printouts. At least as many other notes were received during the initial revision process but were discarded. As can be seen from the table, the notefile provided users with a forum to ask questions of concern to them in their daily lives. In this sense, the lesson provided a rudimentary counseling and referral service, in that some specific physician names were mentioned, and some patients were informed that their physicians were doing an inadequate job of giving them information or treatment, based on medical student opinions and on information provided by the notewriter in the note.

For example, methods of birth control were discussed. A patient asked about a specific brand which was recommended as a birth control method. A medical student warned the patient that this method was a subject of many complaints, as it had caused a lot of hypersensitivity reactions and was "not all that effective, plus you're supposed to wait 10-15 minutes while they melt before having intercourse and some people just don't wait." Other users corroborated this information from personal experience: "Ended up putting my wife in a bad way. And I don't mean itching." "I burned for a whole day after my girlfriend used one." While this type of discussion is certainly no substitute for the physician-patient relationship, it does provide valuable opportunity for the airing of issues and alternatives. As in all discussions, however, the quality of the knowledge and expertise of the participants must be weighed by the reader.

4. Social-psychological implications of computer based interpersonal interactions have not had much study. Tobach, et al (1977) presented a symposium entitled "Invisible Laboratory: Computer Networks and Future Scientific Communities" in which they discussed some aspects of interpersonal contact through a teletype network of some two dozen institutions. Unfortunately their data were anecdotal and pertained largely to requests for file creation and discussions of the weather. Their user population was limited to homogeneous population of researchers. Their conclusions were tentative and quite future oriented, with little reference to present results.

Nelson (1975) makes passing reference to an intercampus rivalry that surfaced in a Plato notefile and served as a catalyst for the crystallization of an "ingroup" in a social system of Plato programmers. The main thrust of that paper was not computer based communication, however, but the dynamics of interpersonal interaction in a single computor laboratory. According to the definition of social system used in Nelson's study (an arrangement of people engaged in an interchange and modification of resources in accord with a discernible set of expectations), the members of the Plato community engaging in discussion in Sexednotes are not a social system. People writing in public notefiles on Plato quickly learn that responses they receive seldom accord with their expectations.

It is apparent, however, that a file such as Sexednotes does serve as an "invisible laboratory" in the sense of a community of users engaged in the common exploration of a set of problems of common concern. Some characteristics of this community can be deduced from an analysis of certain characteristics of the notewriters and their notes. Table V summarizes some data on the note writers and their groups. Many of the writers were medical students and other college students gaining access to the lesson through the medical catalog. Others included practicioners, instructors, designers, and programmers from other systems and other Plato projects including the military, religious organizations, universities, and private business.

Due to the nature of the subject matter, note writers were given the option to remain anonymous. Of the 221 notes on file, 88 or 40% exercised that option. Of the remaining 133 notes, 54 different people representing 43 different groups of Plato users at 24 different geographical locations contributed.

As pointed out in Table IV, the notes sorted themselves into four categories: lesson errors, requests for information, testimonials and thanks, and obscene or kinky notes. These four categories appear in all Plato notefiles regularly, especially the first and second types of notes.

Occasionally in our five years on Plato we have seen instances of testimonials and thanks for a specific lesson, but not often. The fact that so many positive comments came in about this lesson serves as evidence that there is a market for an organized, interactive, legitimate source of information about sex and sexual problems. Despite the weaknesses of the lesson, such as hard to answer questions and ambiguously worded frames, many users felt motivated to comment on its worth, and even to recommend it to their friends and colleagues. "This lesson should be mandatory for everybody over the age of 12." "I certainly will encourage others (nuns of course) to view it." Thus one conclusion that can be drawn from the notes is that the lesson is a valid educational exercise which fulfills a commonly felt educational need.

The fourth type of note, obscene, also appears on Plato occasionally, just as they appear in other public places. However, due to the fact that this lesson specifically deals with sex, it may be expected that the file would draw more notes in bad taste than is usually the case for Plato notefiles. To a surprising extent this has proven not to be the case. We have received only one facetious "knothole" note, one serious advertisement for swinging partners, and one short series of threats toward a specific person from a psychiatric patient. The editors of the file attempt to provide sincere answers to queries and criticisms, and have clearly stated a policy for the notefile which legitimates any sexual topic for serious discussion. Non-serious and crank notes are promptly deleted.

CONCLUSION

This experiment has shown that Plato is an effective vehicle for disseminating information about sex education. In addition, from the beginning the project has been a microcosm of the Plato experience: it was proposed and written by a student and a faculty member whom she thus involved in Plato activity; it was instrumental in adding a new site to the Plato Health Science Network through interinstitutional cooperation of personnel and the subsequent diffusion of interest in Plato from one institution to the other; it makes use of many interactive instructional design features of Plato, including a pretest and posttest, multiple-choice and natural language student input, use of notefiles and student comments; it fills a gap in participating schools' curricula; it has drawn the interest, involvement, and beneficial participation of other Plato projects from all areas of education; and it has spawned an interested subculture of regular users and promoters.

Thus it can be considered an example of successful use of Plato on many levels, which is of interest to students, administrators, teachers, and researchers. An analysis of the reasons for its success may be beneficial to others attempting to promote the use of Plato at their local sites.

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TABLE I: Overall statistics from "Introduction to the Role of the Obstetrician-Gynecologist as a Sex Educator" from May to November, 1978.

1000 entered lesson; 236 completed lesson.
Average time spent in lesson: 7.718 minutes
Average number of items answered: 12
Average correct first try: 7.8

667 completed pretest
Mean Score: 70%
Mean Time: 1.5 minutes

236 completed 10 question posttest
Mean Score: 90%
Mean Time: 1.04 minutes

112 completed 25 question posttest
Mean Score: 90%
Mean Time: 2.80 minutes

Average score of pretest for completers of lesson: 80%
Average time to complete lesson: 17.6 minutes

74 students wrote an average of 1.6 comments.

TABLE II: Section statistics from "Introduction to the Role of the Obstetrician-Gynecologist as a Sex Educator" from May to November, 1978.

Section	Times Begun	Times Finished	Average Time	Average Score	Perfect Score
1	279	263			
2	257	217	2.52	5.0	7
3	249	187	5.45	5.4	9
4	228	171	8.37	14.4	21
5	188	136	7.57	12.0	19
6	204	157	3.50	6.7	10
Total	1000	236 (posttest)	27.4	43.5	66

TABLE III: Item Analysis Statistics from "Introduction to the Role of the Obstetrician-Gynecologist as a Sex Educator" from May to November, 1978.

Total items to be answered: 52

Correct on first try:
- Range: 20% to 99%
- Mean: 68.135%
- Median: 69.5%
- S.D.: 21.696

% correct on first try	# of items
0	0
10	0
20	3
30	3
40	3
50	9
60	8
70	6
80	8
90	12
100	0

TABLE IV: Types of notes and responses appearing in Sexednotes from May 1, 1978 to November 1, 1978, with an approximate count based on available records.

1. Lesson errors: 25 recorded
    - mispellings: 7
    - unaccepted answers: 7
    - disputed facts: 11

II. Requests for information: 137 notes and responses
- birth control: 14
- counseling: 18
- anatomical facts: 28
- medical advice: 11
- sex techniques 66

III Unsolicited testimonials and thanks: 35 notes and responses
Editor comments and replies: 22 notes and responses

IV. Trash: 2 notes (plus approximately 12 that were lost).

Total notes on hand: 221

TABLE V: Note writers and groups in Sexednotes from May to November, 1978.

Total notes anaylzed: 221

Anonymous notes: 88
Signed notes: 133

Different groups: 43
Different people: 54
Geographic sites: 24

University of Illinois, Urbana
University of Illinois, Rockford School of Medicine
University of Illinois, Peoria School of Medicine
University of Illinois, Abraham Lincoln School of Medicine
University High School, Champaign
University of Indiana
Sangamon State University
University of Tennessee
Dupage Community College
Kennedy-King Community College
Wright Community College
Malcom X Community College
University of Connecticut
Lutheran General Hospital, Park Ridge
Ravenswood Hospital, Chicago
College of Saint Francis, Joliet, Illinois
University of Oklahoma
University of Maryland
Competative and Responsive Learning Associates, New York
Cornell University
University of Delaware
Illinois State Prison System
Sheppard Air Force Base
Southern Illinois University

PLATO SIMULATION FOR PROCESS OPERATOR TRAINING

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INTRODUCTION

The effectiveness of process simulation instruction has been proven by such diverse industries as petroleum, airlines and shipping in their utilization of mechanical simulators to deliver highly transferable training. In order to demonstrate PLATO's training potential in a process control environment, Control Data Education Company consultants and CAI specialists, interfacing with subject experts from Union Carbide, Texas City, Texas, have analyzed the training needs for operators of a specific chemical unit and developed a tutorial-simulation program. As suggested by this model, PLATO process simulations may be the best way to bridge the vast gap between costly mechanical simulators and common instruction.

BACKGROUND

The operators compose a target population of widely varying age, experience and ability. Many possess minimal basic skills, some have virtually no chemical or process control background, and others stubbornly stick to undesirable procedural habits and misconceptions acquired over decades of OJT. Yet their jobs require them to monitor and control a highly technical, complex and volatile chemical process by means of various meters, indicator lights, levers and instruments. Inconsistent performance on their part reduces the unit's efficiency and endangers the safety of fellow workers. Operator errors which cause unit down time reduce plant productivity and profitability.

In addressing such problems, PLATO process simulation attempts to:

1) improve operator understanding of the processes involved by graphically displaying the workings of the unit as controlled by the user
2) improve operator sequence of action under certain conditions
3) improve operator reaction time to a given situation.

Subject experts provided a rudimentary sketch of a relatively simple transfer and storage unit (Figure 1). This diagram, using standard engineering symbols, displays an ethanol inflow line, feed tank, pump, outflow line, make-up and venting nitrogen lines, six hand valves (HVs), four diaphragm motor valves (DMVs), and the instrument control panels through which an operator manipulates the process of ethanol inflow and outflow. Instructional design converted this unit into a two-part simulation which now resides in lesson "hoptrain" on the CDC "minna", "quebec" and "brussels" PLATO systems:

1) an interactive procedural exercise in start-up and stabilization of a simulated ethanol feed tank unit
2) a troubleshooting problem requiring quick diagnosis of a feed tank leak and appropriate corrective action.

MODEL

The simulated unit is displayed on PLATO in basically two parts (Figure 2). The top half of the screen graphically portrays the actual ethanol unit: inflow, outflow and pressure lines, a 250 gallon (100 inch) tank, pump, hand valves and diaphragm motor valves. The lower portion of the screen contains the pump on/off switch and three instrument controllers which regulate the key unit processes: inflow, level (= inflow-outflow) and pressure. The display also includes a "HELP available" message and an "Elapsed time" box.

Each instrument controller can operate in either manual or automatic mode. Manual mode allows the student to set p.s.i. on the DMVs, which are either air-to-open (DMVs 1, 3 and 4) or air-to-close (DMV 2). In automatic mode the user directly sets the process rate: gallons-per minute (g.p.m.) for inflow (0-250), inches (0-100) for tank level, or p.s.i.g. (0-100) for tank pressure. The simulation will adjust p.s.i. on the corresponding DMV whenever a controller is in automatic mode. The controllers also include a strip chart recorder which dynamically graphs the on-going status of each process.

PLATO's basic routine: 1) checks for and accepts new user input, 2) updates calculations of key variables, and 3) replots accordingly. Within this complex loop (Figure 3) students can open or shut the hand valves, start or stop the pump, control inflow and out flow rates, regulate system pressure, or request and receive on-line assistance.

The graphics are rendered dynamically interactive through the flexibility of the TUTOR language, the PLATO terminal's touch-active CRT, and the speed of CDC's solely-dedicated CYBER 73 mainframe. The valve symbols are outlined or filled in depending on whether each is currently open or shut. The pump symbol in the unit diagram rotates if the pump is on. The feed tank itself fills or empties to an accurate level, according to ethanol inflow and outflow rates controlled by the operator. A flashing alarm appears when level in the tank is less than twenty inches or greater than eighty inches. The pressure relief valve (HVO) spurts if it is open and tank level exceeds seventy inches. These graphic capabilities allow students to visualize the results of their manipulation of the controllers. This impact cannot be obtained in either an actual operating unit or in a mechanical simulator.

The student's objective is to adjust the unit so that processes (ethanol transfer and storage) begin and are brought to "stable" operating conditions. For the purpose of this simulation, stabilization is defined as inflow equalling outflow for at least thirty seconds, with all controllers operating on automatic mode. If the user requires assistance at any time, HELP is available which provides each and every step, in proper sequence needed to accomplish the goal:

1) Open hand valves 0, 1, 2, 3 and 5 by touch them
2) Set ETOH inflow controller to manual at 3-15 p.s.i.
3) Open hand valve 4
4) Turn on pump
5) Set level controller to manual at 3-15 p.s.i.
6) Set inflow and level controllers on Auto
7) Set the split-range pressure controller on Auto
8) Wait for tank to level out

Students can achieve stabilization in as little as three minutes, depending on their knowledge of the ethanol unit and familiarity with the simulator. Otherwise, PLATO will continue looping indefinitely until the criteria are met. Of course, users can also terminate the activity by adjusting the model so that the unit simulates an explosion due to excessive tank volume and/or pressure.

The PLATO system's built-in data collection and analysis features assess student achievement by monitoring how the simulation is operated. Instead of being evaluated by pretesting/posttesting, the learner's progress is measured by variables relating to time and sequence of performance.

The simulation can monitor and record such data as:

- whether stabilization is achieved
- how much time the student uses to reach stabilization
- how many times HELP is requested
- what procedures are initiated and in what sequence

PROCESS TROUBLESHOOTING

Once a student achieves unit stabilization he or she can proceed to a troubleshooting exercise based around this same process simulation. In this case, however, the graphic representation of the unit is removed and the student must work on the basis of the instruments alone. This provides virtually the same environment that an operator would find in an actual unit. PLATO adjusts the controllers so that, while inflow remains constant, tank level, as indicated by the level controller, begins to drop. The student must then diagnose the problem of a leak in the feed tank and take corrective action to minimize ethanol loss.

The program provides tutorial guidance through the diagnostic and corrective procedures if needed. Basically, the operator in this situation needs to make two adjustments to the unit as quickly as possible to minimize fluid loss:

1) shut down ETOH inflow
2) pump out ethanol already in the tank at the fastest possible rate.

By recording the time required for each student to empty the tank, and multiplying that by a factor of gallons lost per second, the total ethanol loss can be calculated. Users acting quickly and efficiently can hold the loss of ethanol to as little as twenty-seven gallons. All students have the option of repeating the corrective procedures as many times as desired to try to reduce their time needed to empty the tank and thus improve their score in minimizing gallons lost.

This model could be programmed with a large pool of potential problems common to the unit which could be randomly assigned to each student upon entering the exercise. In this way an operator would be provided with diagnostic and corrective procedure training for a wide variety of potential situations which otherwise might take years to encounter and master on the job. Using the process simulation in such an application can therefore teach complex troubleshooting procedures in less than real time, without tying up an actual unit or a mechanical simulator, without the possibility of destroying costly equipment or endangering the safety of personnel.

CONCLUSION

Lesson "hoptrain" is a hybrid instructional mode of computer-based training. Far from definitive, though, it continues to be refined and debugged. When the PLATO IST microprocessor is upgraded with sufficient memory, unit diagrams and controller graphics can be downloaded into the terminal, which will significantly speed up the entire simulation capacity. For the petrochemical industry, a whole series of such unit process simulations needs to be developed and intergrated into a broad operator training curricula.

Judging from the ethanol model and other successful PLATO programs developed by the utilities, airlines and medical industries, PLATO simulation training appears to be among the most promising frontiers in Computer Based Instruction. A.D.C.I.S could soon be host to a sizable consortium of process-oriented industrial trainers. The myriad of potential PLATO simulation has already begun to be realized as a desirable method of providing cost-effective, accountable, performance-based delivery of process operator training.

ACKNOWLEDGEMENT

The authors wish to express their gratitude to all persons involved in this project, particularly the Union Carbide subject experts and the management, marketing and support personnel of Control Data Education Company, Southwest Region.

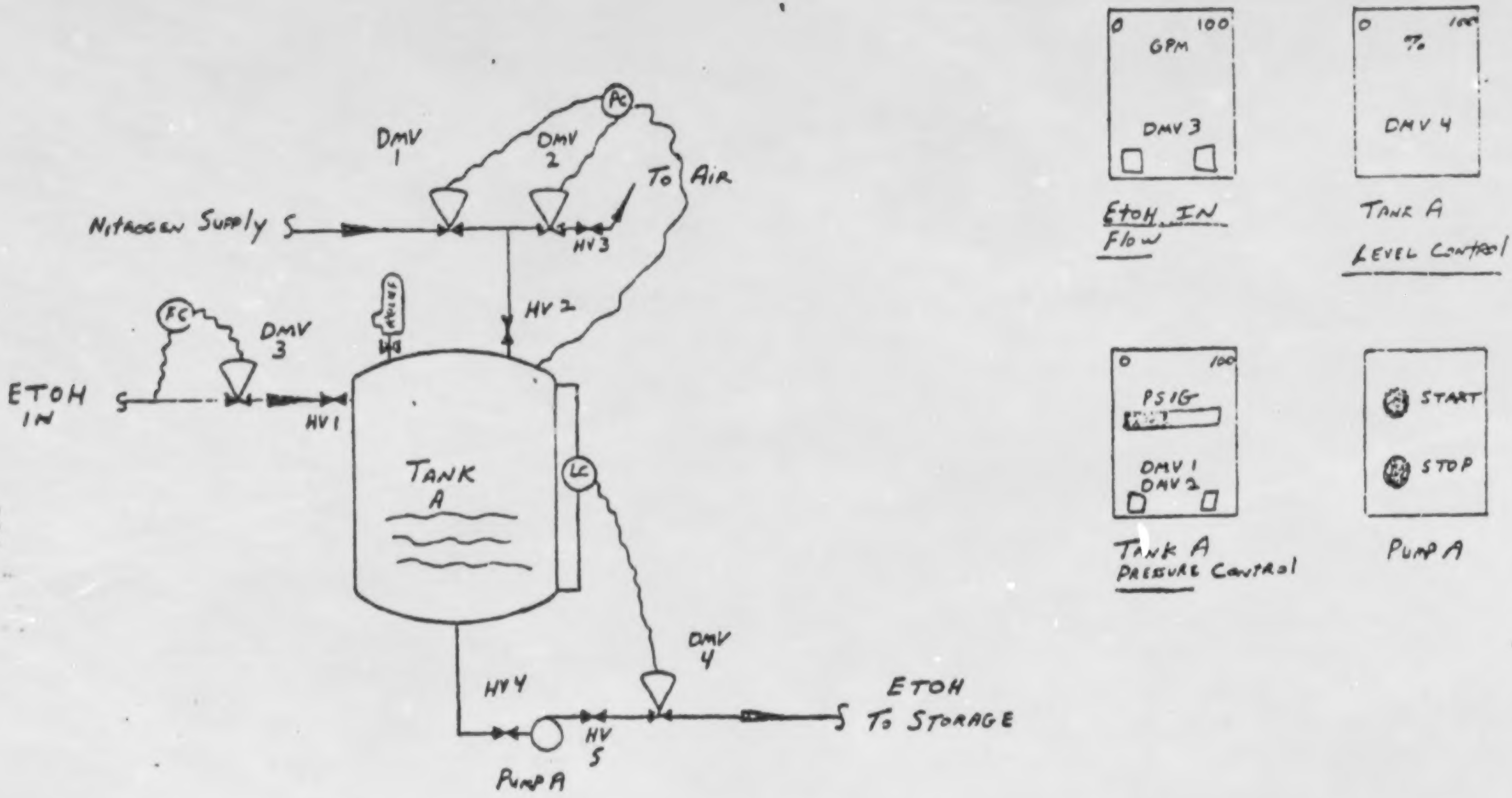
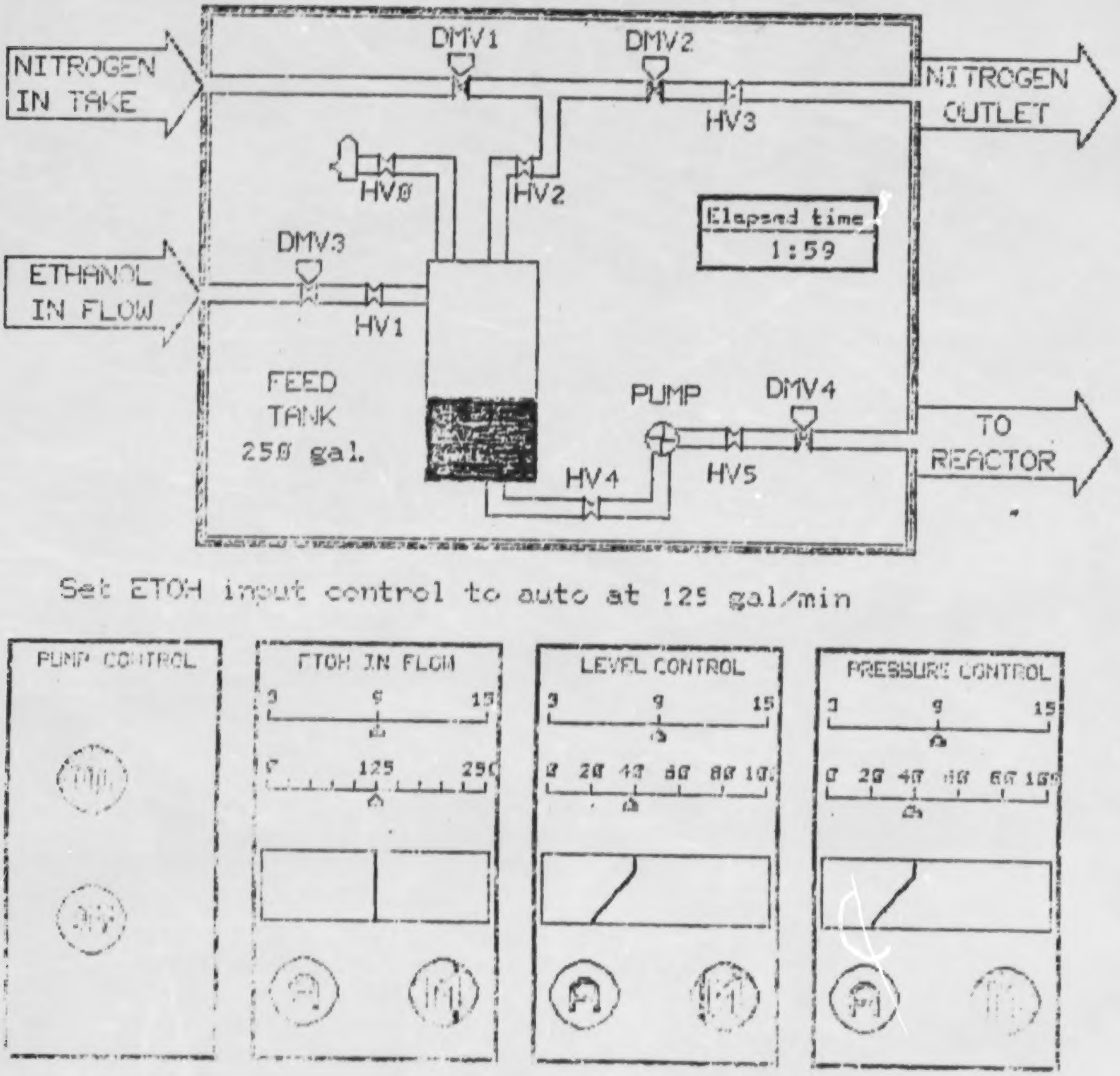

DMV 1
DMV 2
PC
To Air
Nitrogen Supply
HV 3
HV 2
FC
DMV 3
ETOH IN
HV 1
TANK A
LC
DMV 4
HV 4
ETOH To Storage
HV 5
Pump A
0 100 GPM DMV 3
EtoH IN Flow
0 100 % DMV 4
Tank A Level Control
0 100 PSIG DMV 1 DMV 2
Tank A Pressure Control
START
STOP
Pump A

Figure 1 - Original ethanol unit sketch


NITROGEN IN TAKE
DMV1
DMV2
NITROGEN OUTLET
HV3
HV0
HV2
Elapsed time
1:59
DMV3
ETHANOL IN FLOW
HV1
FEED TANK 250 gal.
PUMP
DMV4
TO REACTOR
HV4
HV5
PUMP CONTROL
ON
OFF
ETOH IN FLOW
3 9 15
0 125 250
A
M
LEVEL CONTROL
3 9 15
0 20 40 60 80 100
A
M
PRESSURE CONTROL
3 9 15
0 20 40 60 80 100
A
M

Set ETOH input control to auto at 125 gal/min

Figure 2 - PLATO process simulation

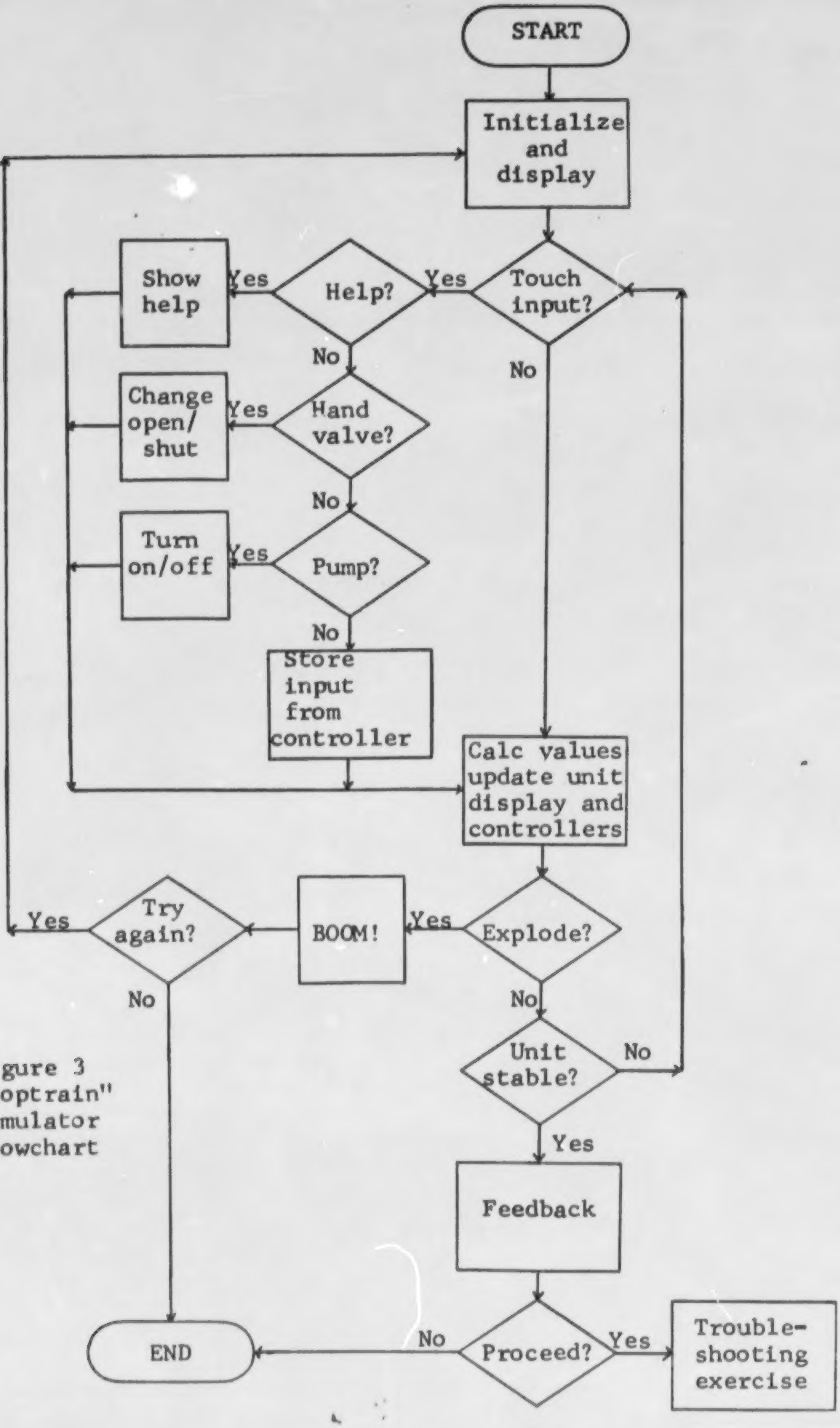

START
Initialize and display
Touch input?
Yes
No
Help?
Yes
No
Show help
Hand valve?
Yes
No
Change open/shut
Pump?
Yes
No
Turn on/off
Store input from controller
Calc values update unit display and controllers
Explode?
Yes
No
BOOM!
Try again?
Yes
No
Unit stable?
No
Yes
Feedback
Proceed?
No
Yes
END
Trouble-shooting exercise

Figure 3
"hoptrain"
Simulator
Flowchart

PLATO IN THE TEACHING OF FOUNDATION VISUAL DESIGN

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Foundation courses in visual design rely on two basic skills on the part of the student in order for the course to provide positive educational value. These skills are:

1. technical or hand skills necessary to implement and present an idea to some viewer, and
2. conceptual skills necessary to the actual mental task of solving a specific problem.

To provide this educational experience to our students, it becomes necessary to separate these two skills in order to demonstrate the strengths and weaknesses of each and to show the relation of both to the process of design.

'Unit Design' was developed to provide a solution to four distinct problems that occur with beginning students in the foundation courses in visual design:

1. the restriction which is placed on the visual presentation of the student's ideas resulting from the level of the student's basic technical (hand) skills;
2. the final solution having been dictated not by the student's aesthetic tastes but by the fact that it is easier to change one's tastes than it is to change the actual design;
3. the difficulty involved in the instructor's evaluation which is due to the different mixtures of technical and conceptual skills of the students, making it hard to separate the two areas for discussion or criticism; and
4. the difficulty for the instructor in presenting an effective criticism to the student (given that the experiences and tastes which the instructor uses for his evaluation are not the same experiences and tastes that the student uses in receiving and evaluating the criticism).

The 'Unit Design' program provides for the designing of a two-dimensional image (called a 'unit') which can be placed into a 4 by 4 array by rotating, mirroring and reversing the positive/negative relationships of each section.

The 'unit' consists of the dot-like elements of the plasma panel, each of which can be on or off, combining to create the desired image. As these dots are in a fixed position, the method for inputing a given image is the same for all students. Having completed the input of the 'unit', the student then progresses into 'design mode' where this 'unit' is used to create a modular design comprised of a 4 by 4 array of 'units.' In this mode the student can alter the 'unit' by rotating 0 , 90 , 180 , or 270 , mirroring from any of those positions, and reversing the positive/negative relationship. The modular design is manipulated until the student arrives at what is felt to be the best, or a series of the best, of the available solutions with regard to the student's aesthetic tastes. These designs can then be judged for aesthetic value in relation to other available designs.

Lesson 'Unit Design' utilizes a dithering process for the input of the 'unit'. Dithering is a process which takes a video image and analyzes the tonal density of small areas.

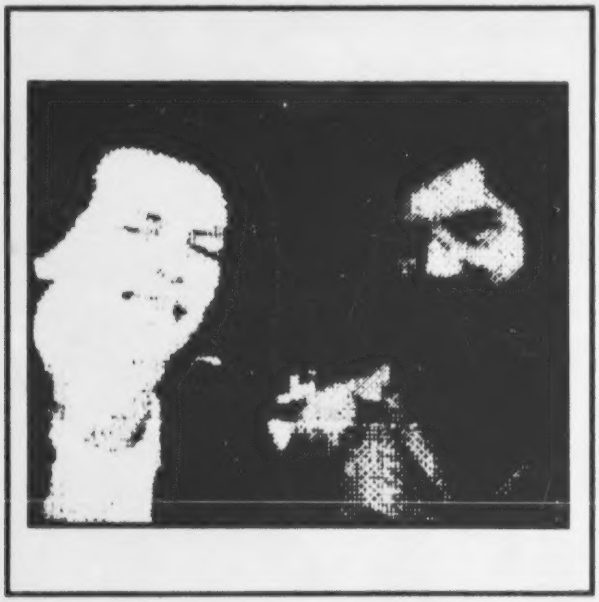

Figure 1

Figure 1 is an example of a dithered image taken from a continuous tone photograph illustrating the detail which can be retained by dithering. These tonal densities are then duplicated on the PLATO screen by illuminating various combinations of plasma panel dots.

The lesson provides the following solutions to the previously stated problems:

1 the lesson reduces the technical skill, necessary for the execution of the design, to a simple matter of using the dithering process to input an image into the computer and editing it by adding or subtracting the fixed dots from which the image is made;

2 the actual execution of the final design is handled through a series of aesthetic judgements on the part of the student and can be carried out by simply touching the computer screen, making any changes necessary to the final form of the design very simple to implement; and

3 students who create images using the 'Unit Design' lesson have utilized the same technical skills so that any evaluation on the part of the instructor will not have to take into consideration the manner (or at least it will be the same for all students) in which the final design was done and can concentrate on the actual aesthetics and design of the piece.

A new problem is introduced when using a plasma panel display device to represent continuous tone pictures. Since the display is a bi-level device, a method is needed to represent individual picture element intensities with minimal altering of the image. Of the various grey scale techniques, 'Ordered Dither' has proven to be the most effective. The process involves comparing the digitized signal with an image position dependent matrix. The values of the matrix determine the success of the technique.

'Ordered Dither' requires circuits designed by Drew White of the University of Illinois to be used with the 'Unit Design' problem. The circuit employs a 2:1 interlaced scan vidicon camera and the logic to digitize and apply 'Ordered Dither' to the image. The logic pulls the video signal apart into its vertical, horizontal and intensity components. 'Ordered Dither' is accomplished by the use of a D/A converter and a high-speed video comparator. Additional components interface the dithered signal with the plasma panel.

A means of storing the image for transmission to PLATO is then needed. A Z-80 based micro-computer system with 40K of random-access memory and a DMA controller is being included to store the image as well as provide editing and compression of the image for transmitting to the PLATO system. The Z-80 will be connected to a PPT via an 8-bit parallel port. The parallel plasma panel has an operating cycle which is slow enough to accommodate White's circuit so that no modifications are required. The only necessary equipment is a 16 bit to 8 bit interface to write the dithered output into memory. Conceptually, the process will go as follows:

1 The student enters a program which loads the necessary routines to process the image.
2 The image is placed in front of the vidicon camera and the dithering process takes place.
3 The student then initiates a routine that will allow him to crop the area he desires to use as a 'unit'.
4 The final step involves the transmission of the dithered image to PLATO and the storage of the image (which has become a 'unit') for student use.

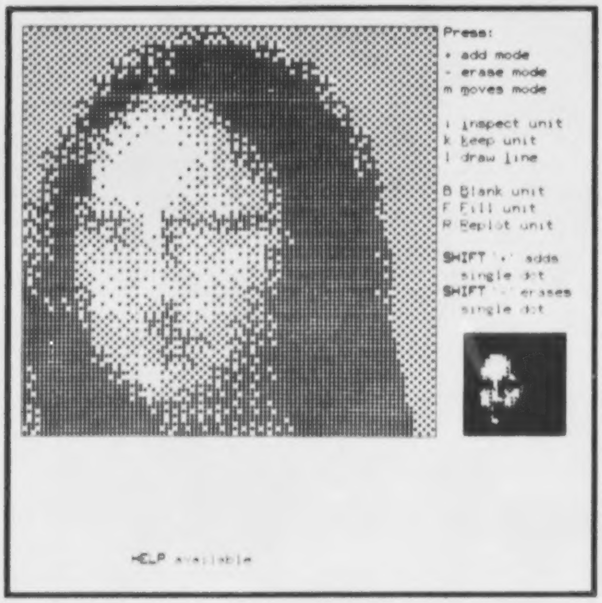
Press:
+ add mode
- erase mode
m moves mode
i inspect unit
k keep unit
l draw line
B Blank unit
F Fill unit
R Replot unit
SHIFT '+' adds single dot
SHIFT '-' erases single dot
HELP available

Figure 2

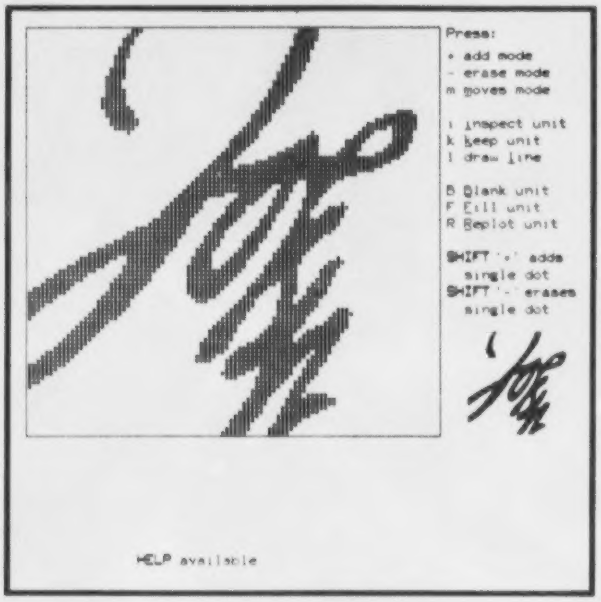
Press:
+ add mode
- erase mode
m moves mode
i inspect unit
k keep unit
l draw line
B Blank unit
F Fill unit
R Replot unit
SHIFT '+' adds single dot
SHIFT '-' erases single dot
HELP available

Figure 3

Figures 2 and 3 illustrate the input of the 'unit' through the 'Ordered Dither' process into the 'Unit Design' lesson. The images can be taken from any two- or three-dimensional source, including objects, continuous tone photographs and printed materials. Both of these displays show the editing section of the lesson where changes can be made to the 'dithered' image.

Estimated times for each process are

dithering of image	1.5 - 2 seconds
selection of unit	user's discretion
transmission of unit	6.5 to 7 seconds

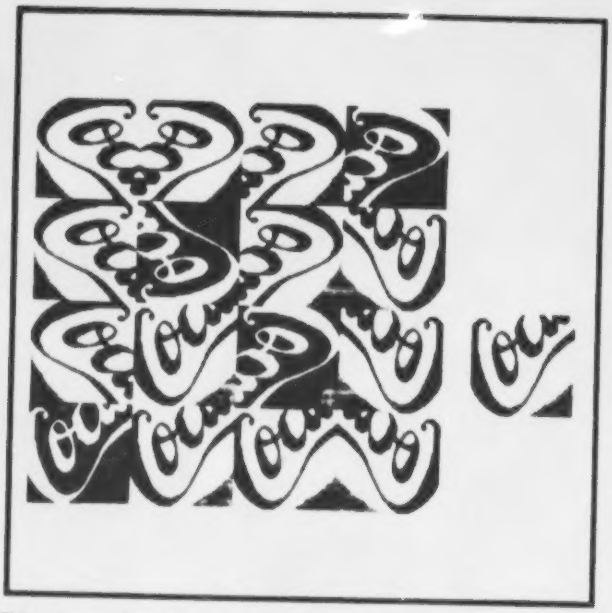

Figure 4

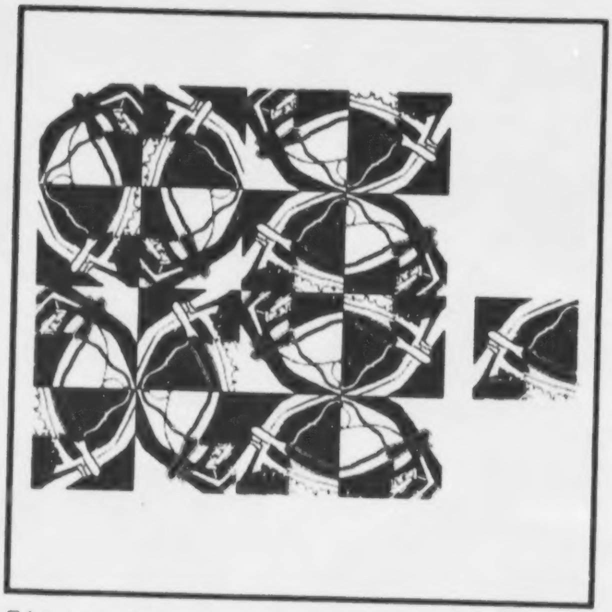

Figure 5

Figures 4 and 5 show final solutions to the 'Unit Design' problem with the implementation of up to 16 versions of a 'unit' in a pattern utilizing rotation, mirroring and reversal of the positive/negative relationships.

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"One-Thousand Terminals Produce a Lot of System Statistics"

Paul Tenczar
University of Illinois

(Paper not received in time for publication)

CAI For Adult Basic Skills Training: Two Applications

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Introduction

Federal, state, and local governments, industrial organizations, and the military are becoming increasingly aware of the need for remedial basic skills training. Concern about reduced achievement levels of elementary and secondary school students has led to the introduction of special programs for improving reading, mathematics, and language skills. Many states have recently introduced competency test requirements for high school graduation. In many community colleges and private and public universities, special training is given to students deficient in basic educational skills. A major goal of the Job Corps is to upgrade educational skills of unemployable young adults.

This paper will describe two adult basic education programs which have been developed to meet the unique requirements of two populations. One project emphasizes an evaluation of the use of computer-assisted instruction (CAI) for basic skills training in the Army. The second project emphasizes the implementation and instructional management of a computer-based remedial education program in correctional institutions. Both projects were developed using the University of Illinois PLATO System (see Smith and Sherwood, 1976 for a description of this system). For the most part, the CAI material consisted of previously existing lessons which had been developed by a number of different lesson authors for use in elementary and secondary schools and in community colleges. Although the two projects were developed independently, the CAI lessons used in each project overlapped considerably.

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[1] The opinions expressed in this paper are those of the author and do not necessarily reflect an official Department of the Army position.

The Army Project

Background

The US Army provides a broad range of opportunities for civilian education and training to soldiers through the Army Continuing Education System (ACES). Instructional services range from remedial reading and English as a second language to graduate school training. Courses are generally provided through contract with local civilian educational institutions and are available at most Army installations throughout the United States and overseas. Programs such as ACES exist in the military, because it is recognized that a better educated person makes a better soldier.

As weapons systems increase in complexity, the skill levels required for successful performance of military duties also increase. Yet the problems associated with lowered achievement levels in the civilian sectors also exist in the Army. Thus, a large part of the ACES Program is directed toward improving skills which have a substantial influence on the ability to develop and maintain military skills. For example, reading requirements for some technical training manuals may be as high as the 12th grade level; yet, the average reading level for an enlisted person falls well below that requirement. Although it may be possible to reduce the required reading level of some manuals, many manuals used for training and maintaining job proficiency cannot be lowered substantially due to the highly technical nature of the material. In cases where the reading skills (or the math or language skills, for that matter) of individual soldiers need to be improved in order to perform effectively their military duties, ACES Programs provide remedial training.

However, there are many problems associated with providing basic skills training to a large number of individuals at many different locations. Because training is provided by many different instructors from many different school systems, the quality, content, and range of instructional approaches vary considerably among duty stations. If a soldier leaves one post before he has completed a remedial skills course, he may have to start over at his next post due to this wide variation in instruction. Remedial basic skills training is provided during on duty hours. Thus, time alloted for this training is time during which soldiers are unavailable to their units, thereby affecting unit efficiency. Soldiers enter these programs with varying abilities and each military occupational specialty requires different mastery skill levels. An efficient basic skills program would match entry skills with required skills. Such individualizing of instruction is difficult to accomplish in a traditional classroom setting. Finally, large numbers of students create volumes of paperwork, particularly in a system like the Army, which must report student progress to many hierarchical levels.

Thus, the problems are numerous. Instruction must be high quality, efficient, standardized, and individualized. In addition, many of the soldiers who require remedial basic skills training are very similar to those in civilian basic skills centers: they are generally high school dropouts with poor reading levels. In the past they have been frustrated by their educational experiences. Often their only reason for attending basic skills classes is that their commander told them to do so.

The Army Research Institute (ARI) has been exploring the use of CAI for many aspects of military training, from using tactical computers as the delivery vehicle for CAI training on how to use that tactical computer to microprocessor-based wargaming methods. A recent extension of this work has been research on using CAI for remedial basic skills training within the ACES Program precisely because CAI promises opportunities for standardized, efficient, and individualized instruction.

An initial study was conducted to determine the instructional effectiveness of CAI for high school equivalency, or General Educational Development (GED) training. The use of CAI was explored in teaching language arts and mathematics. In addition the study sought to identify implementation problems which occur when a new technology is introduced in a military classroom.

Setting

This study was conducted at the Education Center at Fort Belvoir, Virginia, where GED training was provided through contract with the Fairfax County School System. Three instructors taught language arts, mathematics, and preparation for the reading portions of the GED test. Classes were held three hours daily with a half hour break, five days a week, from 8:00 a.m. until 11:30 a.m.

Generally, students in the language arts class spent three weeks in class. The first day was used primarily for pretesting and the last day was used for GED testing on the "Correctness and Effectiveness of Expression" GED test. Thus, these students had about 39 hours available for instruction. The language arts class was primarily platform lecture. Topics included spelling, punctuation, grammar, capitalization, and word usage.

The mathematics class was more individualized, with students moving through modules at their own pace from basic arithmetic to elementary algebra. Students would spend from five days to eight weeks in the mathematics class. The first day was reserved for pretesting, and the "General Mathematical Ability" GED test was taken on the final day of class.

Soldiers at Fort Belvoir took the School and College Aptitude Test (SCAT) before they were enrolled in GED courses. Depending upon their scores, students were counseled to immediately take the GED test, enrolled in GED preparation courses, or enrolled in an elementary reading course. Soldiers in GED preparation might take one, two, or all three of the GED courses.

The evaluation of the use of CAI for GED training was divided into two phases . The first phase was a preliminary period. During this time the current traditional curriculum was analyzed, eight PLATO terminals were introduced into the classroom, instructors were trained in the use of PLATO, and lessons were selected and tried out with sample students. The second phase was the evaluation period.

CAI Curriculum

A CAI curriculum was developed from existing lessons in language arts and mathematics available on the University of Illinois PLATO System. No new lessons were created. In all cases, the selected lessons fit within the framework of the existing traditional instruction. In some cases this led to excluding some potentially useful CAI lessons, but matching curricula as closely as possible was considered an important factor for the evaluation. Instructors reviewed lessons with students and made final decisions about their inclusion in the CAI curriculum. The CAI curriculum did not cover all topics covered in the traditional curriculum. For this reason, and because PLATO was not available to students for the first 45 minutes of the class (at the time, PLATO did not begin service until 8:45 EST), the CAI curriculum was supplemented with traditional instruction.

Design

Thirty-two students in language arts classes and 32 students in mathematics classes were randomly divided into two groups: a traditional instruction group, and a traditional with CAI instruction group. (Actually, the soldiers ended up drawing from a hat because it was quickly realized that they were more easily resigned to being a "NON-PLATO" person if they determined their own fate.) The evaluation of the use of CAI was conducted first in language arts class and then in the mathematics class. Students in the traditional instruction group spent three hours daily receiving standard classroom instruction. Students receiving the traditional with CAI instruction spent about one hour a day using CAI and the remaining time was spent in the traditional instruction. In all cases, students in the traditional group received instruction in the same topics as the traditional with CAI group at the same time. Only the delivery system differed.

Results

The evaluation data indicated that students in the traditional with CAI group performed at least as well or better than students in the traditional instruction group. The average GED scores were 2.75 points higher in the language arts class and 1.56 points higher in the mathematics class for students using the CAI curriculum. Gain scores on the California Achievement Test were also higher for the CAI group than for the traditional instruction group (.53 more years in the language arts class and .38 more years in the mathematics class). Although these differences were not statistically significant ($p > .05$), in all cases the CAI group had the higher scores. More students were likely to pass the appropriate portion of the GED test (45 is the passing score in Virgina) with the CAI curriculum than under traditional instruction alone.

Soldiers in the traditional instruction group, however, improved achievement scores to a great extent, gaining .57 years in language arts and 1.81 years in mathematics in a three week (39 classroom hours) period. Whether or not this is a true gain or the result of increased instructor efforts is yet to be determined.

Several valuable implementation lessons were learned during the preliminary and evaluation phases. The PLATO terminals were installed in the classroom about three months before the evaluation actually began. For the first month, the dedicated phone lines appeared to be dedicated more to breaking down than to transmitting data. This increased distrust in new technology among the the instructors and frustration among students who would try to use the "Machines." Fortunately, the phone line problems were resolved and ARI was allowed to go ahead with the evaluation. Once students discovered that the terminals actually worked and could be used by them, they demanded to use the terminals more often during classroom time. Also, instead of taking the usual half-hour break, soldiers would race to see who could get to the terminals first. Instructors would have to turn off all terminals to get the students back to their classes.

The instructors were worked with on a daily basis to train them on use of the system and to develop the curriculum. Eventually, instructors became more confident in the use of the system and found that their students could handle, and indeed liked PLATO and might even learn something useful. Instead of being a thing to distrust, PLATO in the classroom was seen as a great possibility to teach their students, not only basic skills, but all sorts of classes which are typically taught in an Army Education Center. These great expectations lead to disappointments when CAI lessons were not available in certain topics, or when lessons were available but were of low quality.

These and other problems were resolved and the evaluation was conducted. The CAI curriculum continues to be used on a daily basis for mathematics and language arts training. Additional curricula are also being used to assist in teaching reading and to provide supplementary information on high school and college level subjects.

The Corrections Project

Background

Like the Army, the need for basic skills instruction in prisons is critical. Some 80-90 percent of adult prisoners throughout the United States are school dropouts; more than 50% of these inmates are functionally illiterate. If prisoners are to reintegrate successfully into society, they must have both the skills and the credentials that go with completing high school or its equivalent.

As a result, the educational programs in most prison schools include classes in reading and language skills, mathematics, and some vocational training. But the traditional classroom style of instruction runs into problems in prison: inmates enter, leave, and move between institutions at irregular intervals; these students have a very wide range of needs, from learning to read to understanding science and mathematics; most inmates fear making mistakes in front of their peers; and student motivation and concentration are low.

Unfortunately, the problems do not end in the classroom. When an inmate leaves the institution or is transferred to another correctional center without having completed the requirements for a GED certificate or a high school diploma, the inmate's educational program cannot easily be continued where it left off. Non-uniform educational goals, methods, and evaluation procedures impede accurate interpretation of an inmate's educational records. To establish an appropriate educational program for the transferred, paroled, or released prisoner is often impossible.

The following capabilities of the PLATO computer-based educational system are especially useful for addressing the problems of corrections education:

- o PLATO is individualized, giving each student the lessons needed;
- o PLATO is infinitely patient, allowing each student to progress at his own rate;
- o PLATO is non-threatening and interactive, maintaining the student's interest and concentration; and

- o PLATO is a network, providing a common base of curriculum and record keeping across institutions, both inside and outside the corrections setting.

To exploit these features, the PLATO Corrections Project (PCP)[2] began using computer-based education in Illinois prisons four years ago. The 32 terminal state network includes three adult institutions (the Vienna Correctional Center -- minimum security; the Menard Correctional Center -- maximum security; and the Sheridan Correctional Center -- medium security), one juvenile institution (the Cook County Juvenile Temporary Detention Center), one work-release center (the Urbana Work Release Center -- a community-based half-way house), and the terminals located at the Computer-based Education Research Laboratory, University of Illinois, for PCP development.

The three major components of the PLATO Corrections Project are (1) a pre-GED, GED, and vocational curriculum; (2) a computer managed instructional system flexible enough to meet a variety of student and instructor needs and yet be easily learned by instructors who are not computer programmers; and (3) a training program that familiarizes instructors with the curriculum and the management system.

Curriculum

Thousands of lessons, ranging in subject from beginning reading to nuclear physics, had already been written by PLATO authors on many curriculum projects. From these the PCP staff chose over 500 lessons appropriate for adult students preparing for the GED test and vocational training. In addition, the PCP staff has developed over 50 lessons, which are mastery based and use a sophisticated corrective feedback and drill paradigm. A comprehensive adult reading comprehension and vocabulary program is being developed and pilot tested.

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[2] The current PCP staff includes Martin Siegel, Project Director; Elaine Bruner; Louis DiBello; J. Michael Felty; David Fuller; Mariellen Gilpin; John Gilpin; and Dorothy Silver. The project is partially supported by funds from the State of Illinois, Department of Corrections School District #428.

Computer Management System

The complete University of Illinois PLATO network includes nearly 1,050 terminals spread over a large geographical area and serving many kinds of institutions, from kindergartens to medical schools. To meet requirements unique to correctional schools, a special system was designed within the wider PLATO network for managing instruction in the prisons. This tailor-made system which the PCP staff designed is called the "PCP System."

The PCP System allows instructors to assign each student the topics which fit the inmate's individual educational needs. Data on which lessons the student has been using, how much time has been spent on each, and which lessons have been completed, are always available to the student and to the instructor. For evaluation purposes, questionnaires probe students' attitudes about the specific lessons and about general aspects of the students' educational life. All data collected about students via the PCP System is treated as confidential.

Communications between students, instructors, and PCP staff are provided so that problems can be quickly identified and dealt with. However, for security reasons, students are unable to communicate with other students via PLATO.

Instructor Training Program

Instructors have to be comfortable with a new technology to use it with students and to teach other instructors to use it. Thus the PCP system was designed to minimize training needs: instructor options were made as clear and simple as possible, all directions appear on each screen display, and, once the instructor has chosen a particular option, the PCP System anticipates the next decision and takes the instructor directly to it.

The PCP staff conducts a two-day training workshop for instructors from each new site, and provides each instructor with a copy of a step-by-step handbook on the use of the PCP System. This handbook serves as a handy reference and also as a guide for training other instructors at the institution.

Currently, a small cadre of professional staff monitors the sites via computer from the PCP center at the University of

Illinois. However, the options supplied by the PCP System, and the training PCP provides for instructors, allow each site to be largely self-sustaining. In a production version, the network of sites could be considerably increased with relatively modest increases in the size of the PCP central staff. Such an expansion of the PCP System has occurred already in Minnesota and the final negotiations for implementing the PCP System in the Philadelphia Prisons is underway.

Usage

Instructional devices, such as audio-visual equipment, often sit in closets unused. One measure of PLATO's success at the institutions is that it has been used heavily by students and instructors.

During the first 2.75 years of regular use since February, 1976, some 2,200 Illinois inmates used PLATO for about 35,000 hours, while 225 instructors, corrections officers, and counselors used PLATO for about 13,500 hours. At all sites students spent about 45 minutes to an hour using PLATO on those days when PLATO was made available to them. There were, however, striking differences in the ways the sites chose to use PLATO.

At Menard PLATO prepares students for the GED. Students spend three to six months preparing for the GED, either receiving instruction on PLATO or in a traditional classroom. PLATO students work on PLATO only as long as they are working on their GED. During recent months there has been a shift toward pre-GED or adult basic education instruction on PLATO since there are increased numbers of low-performing (below 6th grade) adults entering the institution. At Sheridan the PLATO GED instructor supplements the PLATO lessons with regular workbook exercises. Each GED student spends a total of about 12-15 hours per week in the program. At Vienna PLATO is used in many programs: adult basic education, GED preparation, college level, and also vocational programs. The student's total academic time is divided between PLATO and non-PLATO classes. At the Cook County Juvenile Temporary Detention Center, PLATO is used to supplement classroom instruction. Students at the Center typically are short-term residents and are working toward grade school or high school certification. Students from the Urbana Work Release Center work during the evenings at the terminals located at the University of Illinois. They use PLATO for supplemental instruction for the GED.

Student and Instructor Attitudes

If CAI is going to help school dropouts acquire basic educational skills and credentials in prisons, it must be attractive. Do students like PLATO? Do instructors like it? In order to find out, attitude questionnaires were given to students from time to time via PLATO. Observations of student behavior, as well as open-ended comments and messages collected via PLATO, were also used to measure attitudes toward PLATO.

During the student's time on PLATO, about six short questionnaires are administered over time. These showed that students liked PLATO, thought it was easy to use, and that they wanted more time for PLATO. Their attitudes toward school and toward themselves as students were good. Many students commented that they appreciated the privacy of PLATO: "when you make a mistake on PLATO it's just between you and the machine; you don't have someone telling you that you're stupid and can't do it."

Although in most cases students are assigned to PLATO, as opposed to choosing it, only about three percent drop out of PLATO or ask to be transferred. The PLATO materials induce active engagement by the students. Once they start, most become PLATO enthusiasts.

The improvement in student attitudes is marked enough to be apparent to prison personnel. For example, the Menard PLATO site director stated in a letter to the Department of Corrections (October 18, 1976), "The students' response to PLATO has been extremely positive. PLATO students have a better attendance record and students enjoy working with PLATO. Students have remarked, 'you can't fool PLATO like you can regular teachers.'" At the end of his letter he wrote, "The students must be asked to leave when their class time is over. Before [PLATO] they couldn't wait to get out of the room."

Instructors also like PLATO. For example, they comment that PLATO has helped them to deal with the constant flow of students in and out of their courses and that PLATO saves time so they are freer to give individual help to students. One instructor estimates that he can save two to three weeks of work by having the student learn some skills on PLATO, then return to class to go on to new material. The instructors have also commented that PLATO gives them more ways to teach their subject.

The PCP staff has encouraged the use of PLATO by all correctional personnel. Security people and counselors at the institutions report that PLATO "opens up their day." Recreational games on PLATO (available to staff only when students are not in school) provide a relief of tension. Some corrections officers and instructors use PLATO to study university subjects on their own. Several students first learned of PLATO from a counselor or a corrections officer. Many prison staff members consider a major payoff of PLATO to be the increased common ground between students, instructors, counselors, and security staff.

Effectiveness

But enthusiasm for PLATO is no substitute for instructional effectiveness. Realizing this, the PCP staff has begun collecting systematic data on effectiveness. Use of the PCP mastery-based drill-and-test lessons on the U. S. and Illinois Constitutions, for example, has been associated with dramatically improved student results on the constitution test required for the GED in Illinois.

The passing score on the test is 30. To date, the following results have been recorded for the 80 PLATO and 77 non-PLATO students who have taken the test since the lessons became available. The average scores on the test are:

Non-PLATO	29 points
PLATO	40 points

while the average amounts of time spent in learning are:

Non-PLATO	16 hours
PLATO	4 hours

Although this has been an informal field study rather than a carefully controlled laboratory study, these differences are so large that they are almost certainly real. In fact, the instructors and students who use the lessons regard their superiority as obvious.

Achievement scores on overall GED tests given at Menard and Sheridan (which have a GED-based program) have been collected during the last two years. The GED scores of PLATO students have been as good or better than the scores of students in traditional classrooms, in spite of the fact that the PCP curriculum does not yet have a comprehensive GED program. At Sheridan, where the PLATO (with workbook supplements) students were compared to the classroom-only students, the PLATO group (n = 52, mean = 236.981, s.d. = 22.551) scored significantly higher ($p = .0175$) on the GED test than the classroom-only group (n = 72, mean = 228.153, s.d. = 15.059). Moreover, 71.2% of the PLATO group passed the GED test, whereas only 59.7% of the classroom-only group passed the GED test. (Note that students were not randomly assigned to each of the two groups; however, pretests did not indicate significant differences ($p > .05$) between the groups.) The Sheridan data summarize seven separate administrations of the GED test.

It seems, in addition, that PLATO students complete their GED instruction in less time than classroom-only students. PLATO students are certainly well motivated, often showing up for their PLATO class while other students skip school for a movie.

Conclusion

The Army Research Institute and the Illinois Department of Corrections view the results of their respective projects as successful enough to warrant continued exploration of the applications of CAI for basic skills training. The focus of the Army's program has recently changed from high school equivalency training to remediation of educational skills required for military duties. The Department of Corrections' program will expand to include new institutions with a focus toward the development of a model statewide network for GED and adult basic skills training.

The "off the shelf" CAI lessons used in both projects need to be reworked and expanded. Ultimately, a coherent, individualized, and mastery-based basic skills curriculum for educationally disadvantaged adolescents and adults needs to be developed. (Currently available basic skills learning systems from commercial vendors are unsatisfactory.) Moreover, research will be needed on ways to maximize training effectiveness of CAI materials through improved instructional strategies and a better understanding of the adult learning process.

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PLATO FACILITATION OF PRECISION MOTION ANALYSIS IN BIOMECHANICS

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INTRODUCTION

In the analysis of sport activity, it is necessary to identify the basic laws and principles that help explain the appropriate techniques for its execution and to identify the mechanical reasons for success or failure. This process of analyzation is frequently referred to as the application of the principles of the sport science of Biomechanics. The purpose of this process is to aid in our understanding of a skill which hopefully will result in improved human performance through better teaching and coaching.

The analyzation process in Biomechanics includes two basic methods. The first and perhaps the most important of which involves the qualitative evaluation of human movements by various forms of visual inspection. The Qualitative Method represents one of the most important analytical tools used by physical educators, coaches, physical therapists, orthapedic clinicians, and by industrial engineers.

The second and most rapidly expanding method involves the specific quantification and objective measurement of selected mechanical characteristics of human performance. The Quantification Method requires the precision motion analysis of motor skills through the use of mathematics. As a consequence, we are able to classify and express relationships in a highly objective and precise manner.

The entire process of analyzing and quantifying movement, when combined with feedback to the athlete, has proved to be an important factor leading to improved performance in sport. Due to the precision of the Quantified Method, physical educators and coaches can more frequently make critical judgements in teaching sport skill techniques based upon concrete evidence rather than guesswork. It is for this reason that the objectivity of research projects involving the second approach is preferred over that of strictly qualitative analysis of performance.

The general framework of research within the field of Biomechanics, as applied to sport, chiefly involves the use of various types of photographic instrumentation techniques. High speed cinematography along with appropriate precision motion analysis procedures presently represents one of the major sources enabling mechanical interpretation of movement in sport.[4]

Once appropriate film recordings are acquired there are several basic types of film data reduction techniques that can be used to obtain quantified measurements. Pioneers in cinematography identified a time consuming procedure whereby images were projected onto a flat surface. Measurements were obtained by identifying segmental end points of anatomical joint centers drawn onto appropriate graph paper. Segmental and total body centers of gravity, as well as linear and angular measures of displacement, velocity and acceleration could then be determined by students utilizing this approach. This procedure is extremely tedious and subject to considerable measurement error as well as student frustration. For example, the accurate analysis of a single frame of film requires 84 mathematical steps simply to calculate the location of centers of gravity for a total of 14 body segments. In addition, 30 steps are required to determine the total body center of gravity location. As a consequence, a total of at least 114 steps (approximately 45 minutes in duration) requiring addition, subtraction, and multiplication are necessary to obtain a single total body center of gravity position.

In an effort to simplify this procedure for students, Francis and Boysen from Iowa State University have worked on the development over the last few years of a method of film analysis for students involving the use of a PLATO Instructional Computer System.[2] The Department of Physical Education at Iowa State did not possess the highly expensive equipment necessary for the reduction, analysis, and storage of cinematographical data. As a consequence, they developed a low cost device which permitted a standard 16 MM sports analyzer projector and plasma panel PLATO terminal to perform all these functions. Unfortunately, portions of this system are currently undergoing software programming for future utilization purposes by students.

PLATO, which is an acronym for Programmed Logic for Automatic Teaching Operations, was developed at the University of Illinois in the 1960's.[5] It was designed to provide computer-assisted instruction (CAI) in teaching a variety of subject matters on many campuses.[3] Recognized as one of the leading systems of teaching by computer, PLATO enables the student to receive visual information in words, figures, graphs, pictures, and sounds. This system is therefore concerned with on-line use of computers by students to further individual learning, by teachers to supervise instruction, by programmers to prepare instructional material, and by researchers to study the optimization of learning.

PURPOSE

The purpose of this study was to explore an additional application for PLATO. Specifically, an effort was made to determine the feasibility and value of using PLATO in the precision motion analysis of high speed cinematographical data by students in Physical Education. This would be accomplished within the realm of undergraduate research projects as performed in the sport science of Biomechanics.

PROCEDURES

Appropriate PLATO software was required in order to accomplish the purpose of this study.[1] Upon software completion, all undergraduate students in Biomechanics at the University of Delaware during the 1978 academic year were randomly assigned to two groups. A control group (N=46) performed all calculations necessary for the completion of a laboratory research project without the aid of a computer system. The experimental group (N=46) was assigned to the PLATO system. Identical research objectives were required of both groups which were necessary for the successful completion of all projects.

Biomechanical projects typically involved descriptive mechanical interpretations of performance at various levels of skill competence. Student knowledge acquisitions involved the solving of delimited motion problems in mechanics, accurate motion/temporal description, and interpretive summarization.

A 16 MM Locam Camera (model 164-4DC), set to operate at 100 frames/second, was used to photograph students in the performance of a selected sport skill technique. Appropriate cinematographical procedures were followed to enable the precise assessment of selected kinematic factors of performance.[4] Student topics included such activities as the sprint start in track and field, altered slope treadmill running, various jumps in figure skating, grab start in swimming, and even the kinematic gait analysis of a thorough-bred race horse.

Initial film measurements, including the digital coordinates of 19 segmental end points of the body, were acquired with the use of a Vanguard Motion Analyzer (model M 16-C) and a Hewlett-Packard System that included a programmable calculator (model 9100B) combined with a digitizer (model 9107A). Approximately ten PLATO terminals were then made available, on an assignment basis, for students in the experimental group. The previously developed computer program for PLATO, entitled "FILM MOTION ANALYSIS," was used to reduce the film data.[1] Following simple instructions coordinate data and other information could then be inputed into this program. This enabled center of gravity determinations and storage for up to 10 frames of film. Kinematic components of both linear and angular velocity were obtained at the same time. Aspects of acceleration were also calculated along with measures of selected joint angular displacements. Graphic representation of body and center of gravity positions were then provided by PLATO in both single and multiple images.

RESULTS

Consistent with the purpose of this investigation, several academic parameters of student achievement were recorded for both groups. Specifically these parameters included objective measures of the time necessary to quantify film data, numerical project grade assigned and the final course grade (not including project grade) received by all students. The descriptive statistical results for these variables are displayed in TABLE I.

TABLE I

Means, Standard Deviations, and Percent Differences for Academic Variables

Variable	Control Group (N=46)		Experimental Group (N=46)		Differences Between Means
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	%
1. Project Hours	15.78	3.10	6.48	2.12	58.9
2. Project Grade	82.96	5.68	88.02	5.36	5.7
3. Course Grade	79.87	8.57	82.78	6.42	3.5

In order to test the significance of the differences between means, a multivariate analysis of variance (manova) was conducted to compare selected variables measured for the Control and Experimental groups (see TABLE II). Project hours, or the time required to complete film data quantification, was found to be 58.9 percent less for students in the Experimental group. Those students using PLATO required an average of 6.5 hours as compared to 15.8 hours for the control. The F-ratio for this variable was statistically highly significant. Students using PLATO had additional laboratory time in which to more thoroughly evaluate mechanical measurements. As an additional result, PLATO provided a significant increase in the amount of individualized instructor time available for proper interpretive analysis of data by each student.

In the second variable, identical objective criteria were used to evaluate the project grades for

TABLE II

Multivariate Analysis of
Variance for Selected Variables
in Control and Experimental Groups

SUMMARY ANOVA (df = 1,90)		
Variable	F Ratio	Significance
1. Project Hours	282.07	*
2. Project Grade	19.35	*
3. Course Grade	3.40	
4. Overall Discrimination	73.53	*

* Significant at the .01 level

both groups of students. An F-ratio of 19.35 was obtained. This indicated that a definite improvement in the overall quality existed for those projects completed with the assistance of PLATO.

The low F-ratio obtained for the variable of Course Grade suggested that the two groups of students were essentially equal in overall academic capabilities for this investigation.

CONCLUSIONS

Within the limitations of this investigation, the simplistic application of computer assisted instructional techniques as provided by PLATO (in comparison to long-hand procedures) resulted in the following measurable benefits:

(1) Considerable decrease in overall data reduction and quantification time (58.9%);

(2) Accurate film data reduction and greater elimination of human measurement error;

(3) Tremendous increase in quantity of quantified film data; and

(4) Greater excitement, as indicated by student evaluation of PLATO, in the conduct and understanding of biomechanical research applications.

PLATO facilitation techniques unquestionably enhance the quality of all student projects involving film analysis in the sport science of Biomechanics.

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AIDS: The User's Guide to PLATO

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This morning, I sat down at my PLATO terminal and told it who I was. It offered some signs of recognition, so after I verified that it was really me, I was informed that there were some personal communications for me that I had not seen. Among them, there was an ominous notification that an instructional lesson for which I am responsible had concluded some poor student's PLATO experience for the day with

```
****EXECUTION ERROR****
```

rather than a pat on the back and reassurance that his theorem proving skills were coming along nicely.

The message contained all the gory details concerning the time and place of the incident, the identity of the victim, and the exact nature of my failure to properly anticipate the student's behavior.

I made a cursory check of my remaining notes for more evidence or explanation of the problem, and finding none, I indicated to PLATO that I wished to see the innards of lesson "proof1". Equipped with the elaborately detailed information in the note, I quickly found and displayed the offending line of TUTOR code

```
search  qual,prline,klen,thms,fsto,ans,rlist
```

which is hardly less a mystery to me, a TUTOR language consultant for as almost as long as there has been a TUTOR, than it is to the reader who may not even know that "HELP is available". However, as every PLATO author knows, help IS available in the form of AIDS, PLATO's answer to dial-a-prayer.

So, with my fingers on the keyset and my eyes on the the screen, I found in AIDS that the third argument from the left in a -search- command must never be a negative number, patched up my lesson to avoid the problem in the future, checked out the new version, and returned to reading my notes, all in the space of 4.7 minutes.

Just to keep things in perspective, I looked at the list of PLATO users and found that 487 other students, authors, instructors, and miscellaneous hangers-on currently shared PLATO's resources with me. I asked what time it was, and PLATO replied that it was 9:37 AM Monday, November 6, 1978.

Times have changed. Thirteen years ago, PLATO III was new, and I was new to PLATO. Timesharing among PLATO programmers was implemented on a sign-up sheet. Even-numbered hours were for codechecking and timeslices were limited to 10 minutes apiece. Odd hours were for testing and production (and you got the whole hour). Programs were fed to the computer on punched paper tape, but could be transferred to magnetic tape to simplify subsequent editing.

There was a PLATO program called "proof" then, and although I wasn't its author or caretaker, I had some fairly intimate associations with it, and although the followng didn't really happen, it could have...

The Coordinated Science Laboratory (CSL) where PLATO was located, was doing classified research, and everything was kept locked up 24 hours a day, but other than that, things were very informal. The students who were testing the proof lesson for us watched as we prepared PLATO to run. We mounted the "proof" binary and data tapes, pressed the "autoload" button, the "door" button to activate the interface (it was on the computer monitor, but at one time was on the classroom door) and we were were off and running - almost. Our final check was to see that the keysets were fitted with the "proof" keycaps.

Five minutes after the session started, one student complained that nothing was happening when he pressed a key. Only a minute later, the other student had the same problem. We ran to the computer room to listen for the telltale peeping sound the computer made as it processed keys. No peeps or clicks from the data tape recording keypresses led us to conclude that the program was hung. We excused the students and looked for the latest printout. The displays left on the student terminals hinted at the source of the problem. A core dump might tell us more, so we turned on the printer. In less than twenty minutes, we had pinned the problem down to a
`call  transfr(11,nbg,nch,iq,ig,kt,komp,kfd,nfinbg,12)`
statement (PLATO used a very FORTRAN-looking language called CATO then) that was returning a strange value in nfinbg. We didn't understand quite how the subroutine worked, so we called Masako Secrest, who wrote it, and she explained the problem to us.

By this time 45 minutes of our production hour was gone, but we decided to try to correct the error anyway. We mounted library, source and scratch tapes, typed edit directives to seek and correct the error (nfnbig was misspelled) at the paper tape punch. Then it was:

autoload the system tape
put the edit tape in the paper tape reader
call "edit" at the console typewriter
watch the tapes spin while the edit proceeded
rewind everything
cross your fingers
compile the new version.

We had been careful, so we had a new working version of "proof" ready for testing. We did take a little more than our allotted time, but we were able to atone by forfeiting the codechecking time we had reserved in the next hour.

About that time, Rick Blomme and Scott Krueger came to PLATO from Larry Stolurow's project SOCRATES, a computer-assisted instructional effort that made use of an IBM 1620. They soon saw that the comparative abundance of computational power offered by PLATO'S CDC 1604 and the flexibilty of the PLATO III CRT student terminal were largely going to waste. They envisioned editing taking place at the student terminal, and soon produced PLATO's first on-line timesharing editor, MONSTER, and at least equally as important, helped start a tradition of on line composition, testing, and revision of programs that has persisted as one of the most significant factors in PLATO system design philosophy.

It soon became obvious that Paul Tenczar's TUTOR language, which allowed students to study several lessons simultaneously, was going to replace CATO as the PLATO language of the future. It was also apparent that there could and should be a way to author and test lessons while students were using the system. Not many of PLATO's early designers realized the extent to which that concept would shape its future.

The concept of on-line composition was not without its opponents. PLATO III had only 20 terminals; space for students was at a premium, and authors often had to take their turn at a terminal in the wee hours of the night. But they waited...and composed at the terminal.

By the time PLATO IV had replaced PLATO III and terminals were more abundant, the tradition of on-line composition was well established. Since PLATO programmers did most of their work at the terminal, it seemed reasonable to make a lesson available on line which could answer some of more common questions about the TUTOR language. Don Shirer produced a lesson called "grafpac" to explain his complex system of graphing commands. Other lessons soon followed which listed and explained other TUTOR commands and capabilities. PLATO system staff members noted that this type of on-line documentation was readily available to users and easily kept up to date. They decided to support such an effort, and consolidated the lessons under one name, "aids".

Lesson "aids" rapidly expanded to several lessons. Options were added telling something of the workings of the computer behind PLATO, along with other topics ranging from available publications to suggestions for effective lesson design. Today, AIDS is an integral part of the PLATO system software. It consists of about 150 lessons with more than 250,000 words of text. Reference materials include classified lists, indexes to detailed discussions of TUTOR commands and features, and interactive lessons to teach and explain complex TUTOR features. It is the complete and authoritative source of documentation of the TUTOR language and provides extensive information about all phases of the PLATO system.

Aside from Elaine Avner's periodicially updated publication "Summary of TUTOR Commands and System Variables", AIDS is the only CERL supported documentation of the TUTOR language which is continuously maintained. AIDS authors take pride and priority in seeing that the information in AIDS is current. AIDS is not available in hard copy. Documentation of new TUTOR features, changes to the language or to documented policies of the PLATO system in general almost always is released in AIDS exactly at the time the changes are implemented. (Pending changes to the system are announced to PLATO users by other means.)

AIDS was designed to help PLATO authors working on-line, and many points of access to the information in AIDS have been provided to facilitate that end. It is accessible to authors and students alike as an instructional lesson. There are special shortcut approaches to system features for printing files, communications options, etc., which include quick access to AIDS. Authors who are entering or revising code in a lesson and who need detailed information on the form or function of a TUTOR feature can, while looking at the line of code, enter a command name or brief concept, exit to the appropriate AIDS discussion, explore other AIDS areas as much as desired, and return at any time to the exact original point of exit. When an error is detected in a lesson, either while being "condensed" (somewhat akin to "compiling") or while being executed, exits to appropriate discussions of the commands and/or error conditions in AIDS are provided as part of the regular system error diagnostic messages.

Initial entry into the AIDS system of lessons may be to the "Main AIDS Index", to the "What Feature? arrow", or to a writeup or description directly accessed as in one of the conditions described above. The "Main AIDS Index" is an index to broad topics. A broad topic, for example "Calculational features", might reference yet another index which then may reference a particular topic such as a general discussion of "variables" or a detailed discussion of the syntax of a command, such as -calc-. A particular discussion may be referenced by a number of different indexes, be reached as a continuation of a related discussion, appear in a series of loosely connected topics, and usually is accessible by several different approaches.

Each AIDS topic is identified by a TUTOR "concept", and may be reached directly from the "What Feature? arrow". Thus one might arrive at the description of the -calc- command by stepping through two levels of indexes, or simply by entering "calc command" at the "What Feature? arrow". AIDS references about 1000 distinct "concepts". Each concept may have many synonymous forms: for example, the concept "calc command" and "changing the value in a variable" are defined as synonomous and reference the same description. The recognition of concepts tolerates minor variations in spelling and the presence of "ignorable" words. Hence, "clac comand", or "changes to value in variabels" are both acceptable variations of the identifying concept. A user can request AIDS to display a concept associated with any writeup to help in finding it in the future.

All requests for features which AIDS fails to fulfill are recorded. AIDS' authors monitor the list of unrecognized requests, and add reasonable variations of existing concepts to the list. Requests for information which AIDS does not currently have are also used in planning revisions.

AIDS users frequently detect typographical errors, unbalanced displays, confusing or unclear descriptions, and once in awhile, outright misinformation. A standard feature of the PLATO system permits users to report these anomalies with a minimum of effort. The authors of AIDS receive an average of about 4 such reports daily, and are usually able to make the necessary changes or corrections immediately.

AIDS has features like "try out the graphing commands" which must be implemented by executable lessons because of the complex nature of the interactions involved. About 70% of the information which AIDS delivers, however, consists of text, simple drawings, options to page forward, review, return to an index, or select a topic from a list. These latter functions are carried out by a TUTOR lesson which interprets simple display and sequencing control commmands. The interpretive approach saves computer resources and greatly simplifies editorial functions. Changes to interpreted AIDS writeups are effective immediately and there is no need to recondense source materials.

A TUTOR "concept" is a word or combination of words from a previously defined vocabulary. When the concepts are encoded, they have the special property of being numerically ordered, so it is possible to do a "binary chop" type search when seeking a particular concept, and consequently, searches through long lists of concepts can be done very quickly. Furthermore, variations in spelling preserve the numeric relationship among concepts, relaxing the demands on user accuracy when specifying a concept to search for. When a new topic is added to AIDS, it is identified by a concept and the concept is added to AIDS' master list. Subsequent references to the new topic are then always made in terms of the concept itself. Thus, if a topic whose identifying concept is "coordinate systems" is to follow as the next topic after the current display a user is viewing, the command "*nextt coordinate systems" would be used to indicate this to the interpreter.

AIDS users are counted and their requests are tabulated. Table I shows the number of AIDS requests, their source, and how AIDS use tends to vary througout the year. Note that mode of entry tends to vary consistently with total volume of use. Volume tends to decrease during the school year when student use is highest.

Table I

AIDS Requests Per Day

Mode of Entry	Sampling Period (1977-78)			
	Nov-Feb	Feb-Jul	Jul-Oct	Oct-Nov
"What Feature?" Arrow	344	385	356	330
TUTOR Editor	309	336	310	291
Total Entries	592	648	590	580
Internal Branches	754	890	820	825
Spelling Errors(%)	6.8	7.2	7.5	6.9
Requests Not Found(%)	8.4	8.7	9.0	8.6

The number of internal branches shown in Table I is an indication of the amount of additional information that a user requests after gaining entry to AIDS which is available through indexes or otherwise directly indicated. User requests for information through the "What Feature?" arrow which are noted in the table are not counted as internal branches.

Table II lists the ten most wanted AIDS features. All references to a feature, both via internal branching and direct user requests are included in these statistics. Many AIDS descriptions return to the main index at the completion of their discussion, which explains the very high popularity of that feature. "Author Resources" is both a prominent choice on the main index page and a very useful index to general PLATO information. The rest of the entries indicate generally those features of the TUTOR language about which users most often need information.

Table II

Number of Accesses Per Day for the 10 Most Requested AIDS Features

Feature	Accesses per day
main AIDS index	61
author resources	39
calculating index	24
display index	23
discussion of "common" variables	20
AIDS "help" page	19
special character production and plotting	18
branching commands index	17
alphabetical list of TUTOR commands	17
functional list of TUTOR commands	16

When most of the descriptions in AIDS were in executable lessons, accessing a particular writeup meant that the computer resources necessary to make all the writeups in the lesson with that writeup had to be available. Waiting periods for these resources were sometimes significant, varying between a few seconds and a few (seldom more than 1) minutes. Records of the waiting times were kept then, but since most displays of information are now interpreted, they have been discontinued. The waiting time to reach an interpreted writeup is almost never longer than a few seconds. When users are making unusually high demands on the system or during periods of degraded service, such as limited (but not fatal) hardware failure, the AIDS interpreter may be subject to frequent breaks in service and then requires an abnormal amount of time, perhaps 30 seconds, to complete a typical 200 word display.

The comments and suggestions which users make about AIDS are many and varied. The following quotes appear exactly as they were received:

"talk about nitpicking but...
the word complete is not underlined all the way. You have:
complete missing one underscore.."

"the entry of the word "iteration" gave me an explanation of how to contact a a plato operator
this seems like an inappropriate response."

Occasionally, suggestions are more highly seasoned with opinion, sometimes good and sometimes not. Here is an exerpt from one we felt like saving:

"...AIDS, and its explanations is an outstanding bit of work, as well as being the best 'user-oriented' documentation I've seen on any system. I'm also constantly finding new and USEFUL routines in (AIDS') library. So in light of this, I just thought it time to say THANKS!!"

AIDS has many authors, but the group principally responsible for its content and maintenance is the PLATO Services Organization. PSO staff consult with PLATO authors and instructors on and off line about all phases of PLATO use. They maintain close contact with the user community; they are intimately aware of user problems and are skilled at providing solutions and at teaching the user how to solve his own problems. Their close ties with the user community and with the system development staff give them a uniquely appropriate background for their responsibilities for system documentation.

THE PLATO DISPLAY IN THE TEACHING OF OPTICAL LETTERSPACING

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Education in the visual arts possesses one very great problem in the student's normal course of study: the ratio of the effort required to 'get an idea' and/or 'make a judgement' and the amount of effort required to put that idea/judgement into practice. It is here that contemporary technology, namely computers and more specifically PLATO, can serve as an educational tool which may become one of the most important changes ever to occur in the education of students interested in the visual arts.

In the graphic and advertising design area of the Department of Art, University of Delaware, we are heavily involved in the teaching of advertising design as visual communication, a subject very dependent on the printed word with an emphasis on the visual appearance of the printed word. When one designs an advertisement or visual communication piece there are two main goals relating to its effectiveness:

1 the recognition by the viewer of the desired objectives of the advertisement, and
2 the actual reading by the viewer of a major portion of the advertisement.

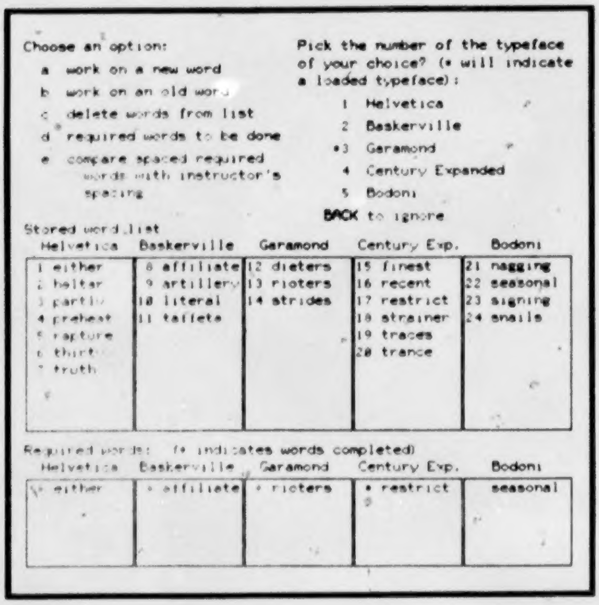
As advertisements are viewed as 'out of context' material in magazines and newspapers (given the reason these publications are normally purchased) it is important that the reading matter be designed as easily readable and aesthetically pleasing as possible.

It is with this readability in mind that correct 'optical letterspacing' becomes a major concern for the designer. Words in headings, subheadings, etc. must be spaced so as to be read easily, trying to avoid the visual division of the individual word into groups of letters smaller than the word itself. Words which break down into small words can create confusion for the viewer, hindering a positive response or adequate comprehension of the subject of the piece.

An example: **LARGE**

Due to the physical form of the letters and the fact that each letter is placed the same distance from each other in this example we, as viewers, begin to perceive the word 'LARGE' as two words, 'L' and 'ARGE' which can create confusion in the mind of the reader.

The problem that occurs in the classroom, where the instruction is aimed at heightening the students' awareness of the spacing and teaching them to make the aesthetic judgements, is the amount of time which is necessary to physically execute the word with enough accuracy and weight that a judgement, resulting in a positive educational experience, can be made as to the correctness of the spacing. Simply outlining (which is the quickest method of executing the letters) does not accurately illustrate the weight of the various letters against one another, and the outlining and filling in of the letters can take from 30 to 90 minutes, even in a fairly rough stage. The more accurate the designer wants the spacing, the more exact the execution must be in the preliminary stages.



Choose an option:

- a work on a new word
- b work on an old word
- c delete words from list
- d required words to be done
- e compare spaced required words with instructor's spacing

Pick the number of the typeface of your choice? (* will indicate a loaded typeface):

- 1 Helvetica
- 2 Baskerville
- *3 Garamond
- 4 Century Expanded
- 5 Bodoni

BACK to ignore

Stored word list

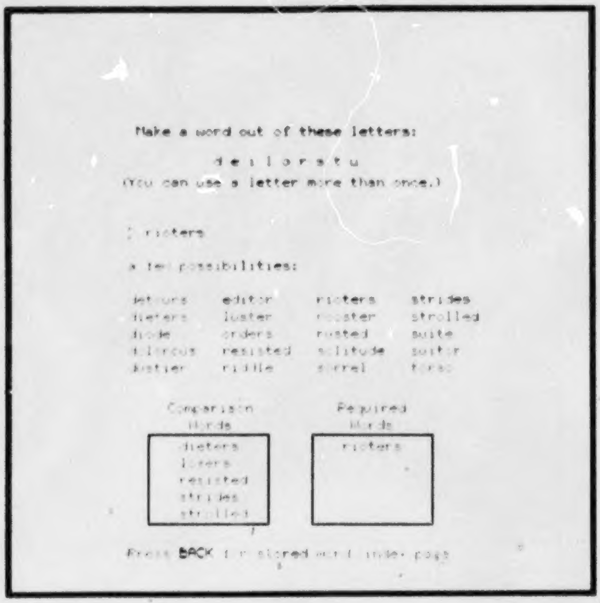
Helvetica	Baskerville	Garamond	Century Exp.	Bodoni
1 either	8 affiliate	12 dieters	15 finest	21 nagging
2 helter	9 artillery	13 rioters	16 recent	22 seasonal
3 partly	10 literal	14 strides	17 restrict	23 signing
4 preheat	11 taffeta		18 strainer	24 snails
5 rapture			19 traces	
6 thirty			20 trance	
7 truth				

Required words: (* indicates words completed)

Helvetica	Baskerville	Garamond	Century Exp.	Bodoni
* either	* affiliate	* rioters	* restrict	seasonal

Figure 1

Figure 1 shows the "stored word page" where the student can choose from the five available typefaces, each representing one of the five major families of type. These typefaces are 1) Helvetica, 2) Baskerville, 3) Garamond, 4) Century Expanded and 5) Bodoni. The page displays the words that the student has spaced and stored and indicates the typeface of each. The display also includes the list of words that may be required for the completion of the lesson which are shown at the bottom of the display in boxes corresponding to each of the typefaces shown directly above. Up to five 'required' words per typeface can be requested for testing and data collecting.



Make a word out of these letters:

d e i l o r s t u

(You can use a letter more than once.)

rioters

a few possibilities:

detours
dieters
diode
dolorous
dustier

editor
luster
orders
resisted
riddle

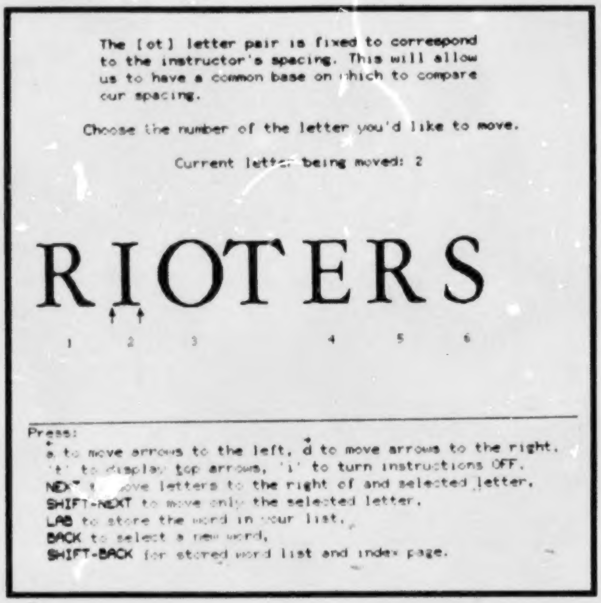
rioters
rooster
rusted
solitude
sorrel

strides
strolled
suite
suitor
torso

Comparison Words	Required Words
dieters losers resisted strides strolled	rioters

Press BACK for stored word index page

Figure 2



The [ot] letter pair is fixed to correspond to the instructor's spacing. This will allow us to have a common base on which to compare our spacing.

Choose the number of the letter you'd like to move.

Current letter being moved: 2

Press:
a to move arrows to the left, d to move arrows to the right.
't' to display top arrows, 'i' to turn instructions OFF.
NEXT to move letters to the right of and selected letter.
SHIFT-NEXT to move only the selected letter.
LAB to store the word in your list.
BACK to select a new word,
SHIFT-BACK for stored word list and index page.

Figure 3

Figure 2 shows the display after the student has chosen one of the five typefaces, in this instance Garamond. The student can then type in any word that he would like to space. The display also shows words which 1) can be compared to those of the instructor so that the student can space the words and get instant visual feedback (comparison words) and 2) words which are required of the student and on which data is kept in order to compare different students' work (required words).

Figure 3 shows the required word, RIOTERS, in the Garamond typeface as it is first shown to the student. Each of the letters is spaced an equal distance from each other except for one letterpair. In this instance the OT has been fixed in the same position as that of the instructor so that the student will have some basis for his judgement on the spacing.

In figure 4 we can see how, through the use of cursor keys located on the PLATO keyboard, each of the individual letters can be relocated. The 'a' key will cause a movement to the left and the 'd' key will cause a movement to the right with the spacing being controllable to 1/60th

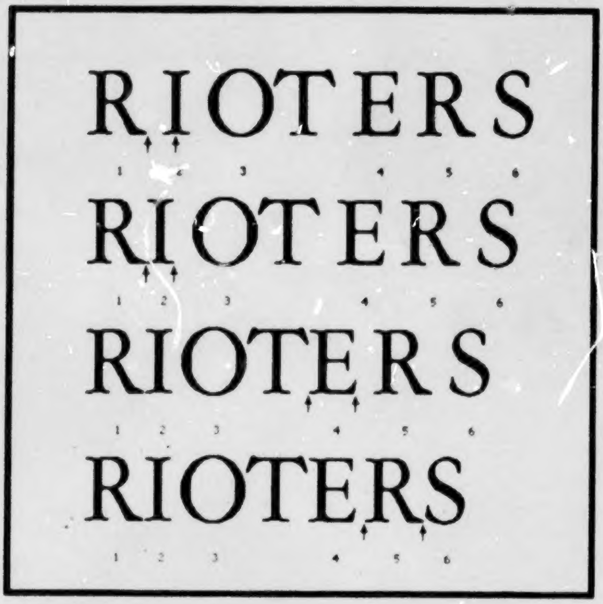


Figure 4

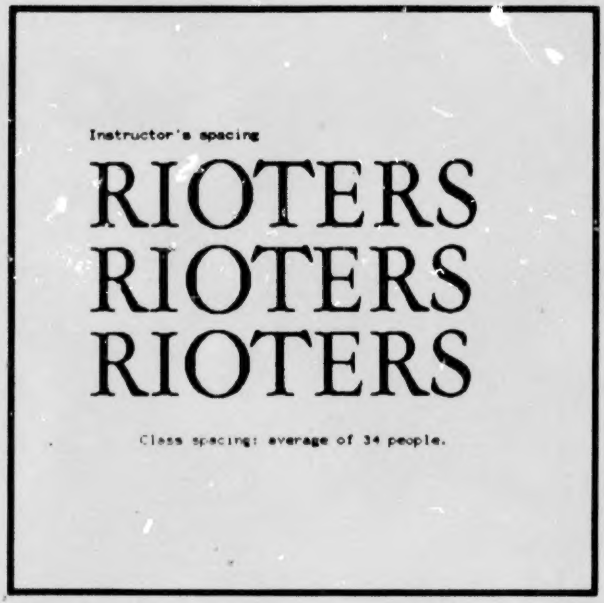
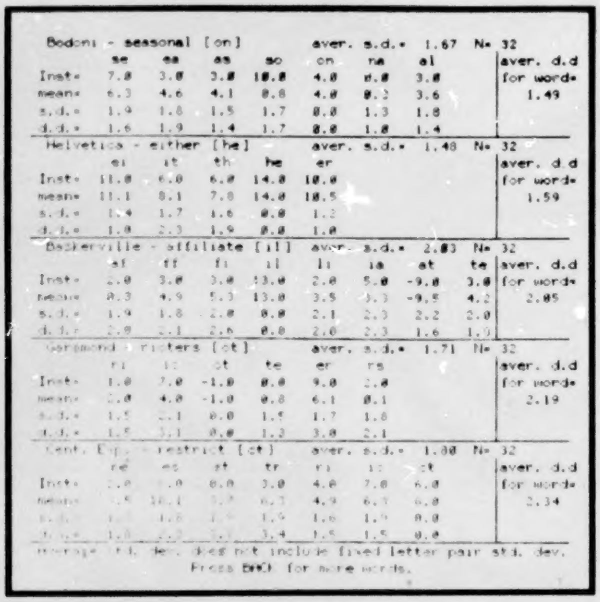


Figure 5

of an inch. As each of the letters are moved the linear space between all letters to the right of the letter being moved stays constant. The bottom spacing is shown as the final step in the spacing.

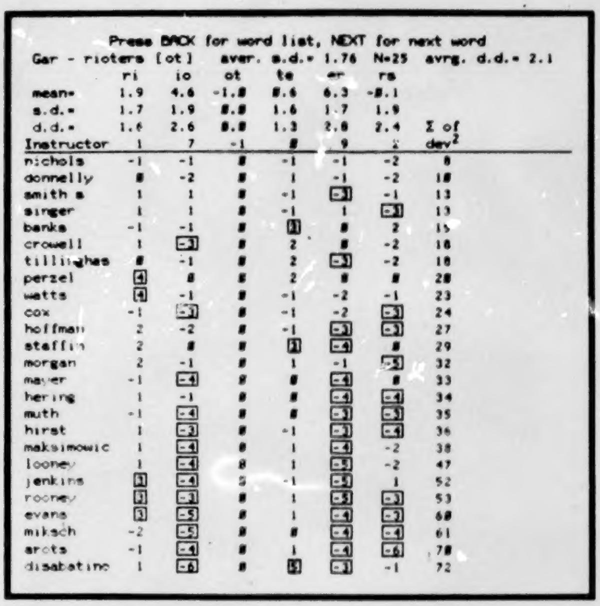
Figure 5 shows the student comparing his own spacing to that of the instructor (top) and to that of an average of the student's classmates (bottom). This gives the student a quick visual comparison of the results and a general feeling for how he has done compared to that of the class. Through PLATO the student involved in 'optical letterspacing' can, in one hour's time, space 10 to 20 words, providing him with considerable practice.

Figures 6 and 7 show examples from a statistical analysis of the students' spacing. The first shows the entire class ranked according to the "sum of the differences squared" providing greater penalty for a large, single mistake with lesser penalties for spreading the error over the entire word. Student Nichols spaced the 'ri' letterpair one dot closer than did the instructor. The 'io', 'te', and 'tr' were also spaced one dot closer with the 'rs' combination spaced two dots closer. The "sum of the difference squared" is therefore 1+1+1+1+4 or 8. It is normally considered 'good' to score under 20. The second figure shows each of the five 'required' words in the order of their difficulty from easiest to hardest based on a



```
 Bodoni - seasonal [on]              aver. s.d.=  1.67  N= 32
         se    ea    as    so    on    na    al       |aver. d.d
 Inst=   7.0   3.0   3.0  10.0   4.0   0.0   3.0      |for word=
 mean=   6.3   4.6   4.1   0.8   4.0   0.3   3.6      |   1.49
 s.d.=   1.9   1.8   1.5   1.7   0.0   1.3   1.8      |
 d.d.=   1.6   1.9   1.4   1.7   0.0   1.0   1.4      |
 Helvetica - either [he]             aver. s.d.=  1.48  N= 32
         ei    it    th    he    er                   |aver. d.d
 Inst=  11.0   6.0   6.0  14.0  10.0                  |for word=
 mean=  11.1   8.1   7.8  14.0  10.5                  |   1.59
 s.d.=   1.4   1.7   1.6   0.0   1.2                  |
 d.d.=   1.0   2.3   1.9   0.0   1.0                  |
 Baskerville - affiliate [il]        aver. s.d.=  2.03  N= 32
         af    ff    fi    il    li    ia    at    te |aver. d.d
 Inst=   2.0   3.0   3.0  13.0   2.0   5.0  -9.0   3.0|for word=
 mean=   0.3   4.9   5.3  13.0   3.5   3.3  -9.5   4.2|   2.05
 s.d.=   1.9   1.8   2.0   0.0   2.1   2.3   2.2   2.0|
 d.d.=   2.0   2.1   2.6   0.0   2.0   2.3   1.6   1.9|
 Garamond - rioters [ot]             aver. s.d.=  1.71  N= 32
         ri    io    ot    te    er    rs             |aver. d.d
 Inst=   1.0   7.0  -1.0   0.0   9.0   2.0            |for word=
 mean=   2.0   4.0  -1.0   0.8   6.1   0.1            |   2.19
 s.d.=   1.5   2.1   0.0   1.5   1.7   1.8            |
 d.d.=   1.5   3.1   0.0   1.3   3.0   2.1            |
 Cent. Exp. - restrict [ct]          aver. s.d.=  1.00  N= 32
         re    es    st    tr    ri    ic    ct       |aver. d.d
 Inst=  [illegible] [illegible] 0.0 3.0 4.0  7.0   6.0 |for word=
 mean=  [illegible] 10.1 [illegible] [illegible] 4.9 [illegible] 6.0 |   2.34
 s.d.=  [illegible] 1.6 [illegible] 1.9 1.6  1.9   0.0 |
 d.d.=   1.0 [illegible] [illegible] 3.4 1.5  1.5   0.0 |
 Average std. dev. does not include fixed letter pair std. dev.
                 Press BACK for more words.
```

Figure 6



```
          Press BACK for word list, NEXT for next word
 Gar - rioters [ot]    aver. s.d.= 1.76  N=25  avrg. d.d.= 2.1
              ri     io     ot     te     er     rs
 mean=       1.9    4.6   -1.0    0.6    6.3   -0.1
 s.d.=       1.7    1.9    0.0    1.6    1.7    1.9
 d.d.=       1.6    2.6    0.0    1.3    2.0    2.4    Σ of
 Instructor    1      7     -1      0      9      2    dev²
 nichols      -1     -1      0     -1     -1     -2      0
 donnelly      0     -2      0      1     -1     -2     10
 smith a       1      1      0     -1     -3     -1     13
 singer        1      1      0     -1      1     -3     13
 banks        -1     -1      0      3      0      2     15
 crowell       1     -3      0      2      0     -2     18
 tillinghas    0     -1      0      2     -3     -2     18
 perzel        4      0      0      2      0      0     20
 watts         4     -1      0     -1     -2     -1     23
 cox          -1     -3      0     -1     -2     -3     24
 hoffman       2     -2      0     -1     -3     -3     27
 staffin       2      0      0      3     -4      0     29
 morgan        2     -1      0      1     -1     -5     32
 mayer        -1     -4      0      0     -4      0     33
 hering        1     -1      0      0     -4     -4     34
 muth         -1     -4      0      0     -3     -3     35
 hirst         1     -3      0     -1     -3     -4     36
 maksimowic    1     -4      0      1     -4     -2     38
 looney        1     -4      0      1     -5     -2     47
 jenkins       3     -4      0     -1     -5      1     52
 rooney        3     -3      0      1     -5     -3     53
 evans         3     -5      0      1     -4     -3     60
 miksch       -2     -5      0      0     -4     -4     61
 arcts        -1     -4      0      1     -4     -6     70
 disabatino    1     -6      0      5     -3     -1     72
```

Figure 7

comparison of the students' spacing with that of the instructor. This display also gives additional statistics such as standard deviation, the mean for all letterpairs and the average number of dots difference per letterpair for each word.

A very special thanks to Charles Wickham who programmed this lesson.

Microprocessor Delivery of PLATO Courseware

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Introduction

Many people today conceive of CAI delivery systems as being either large time sharing systems such as PLATO or small personal computing systems such as the Commodore PET or Radio Shack TRS-80. The PLATO system has demonstrated that it can deliver CAI materials involving very sophisticated displays, with 512 by 512 screen resolution, which may include not only alphanumeric characters, but also line drawings, circles, arcs, user-defined symbols, animated sequences, and student interaction through both a specially designed keyset and a touch sensitive display. The small systems are limited to the delivery of material involving only alphanumeric characters and displays created from a fixed set of symbols with more limited resolution than available on a PLATO system. These small systems, however, possess the advantage of being totally self contained; they operate without the need for external processing power. The conventional mode of operation of a PLATO terminal, on the other hand, requires a communication link to a large computer.

This paper describes a third approach which retains the advantages of the PLATO terminal for presenting instructional material without the need for dedicated access to a large computer. This system, referred to as an off-line system, consists simply of a standard PLATO V terminal (PPT) with an expanded memory and a floppy disk system.

The On-Line PLATO System

There are four major advantages provided to CAI authors by a PLATO system: 1) a large courseware library, 2) a powerful authoring resource, 3) sophisticated management programs, and 4) an electronic communication network.

An on-line user of a PLATO system has access to the most extensive collection of CAI courseware in existence. Over 6000 hours of instructional material have been developed in approximately 150 subject areas ranging from elementary school to the university level.[1]

The on-line user of PLATO is provided with a powerful set of tools designed especially for the production of CAI material. The TUTOR language[2] makes it possible to write, with minimum knowledge of computer programming, interactive instructional material which involves graphics as an integral part of the program. It provides natural language answer judging, number judging, with complete dimensional analysis, many branching commands, and extensive computational facilities.

The inter-terminal communication features of the PLATO system make it possible for authors of CAI material to receive assistance from a staff of on-line consultants regardless of the location of the terminal. In addition, extensive electronic mail features allows information to be exchanged between users who may not be simultaneously on-line. Group note features provide a forum where users sharing common interests can exchange ideas. The use of these communication features provides a method of exchanging information which historically has been conducted by reading journals, attending conferences, and writing letters.

The PLATO V Terminal

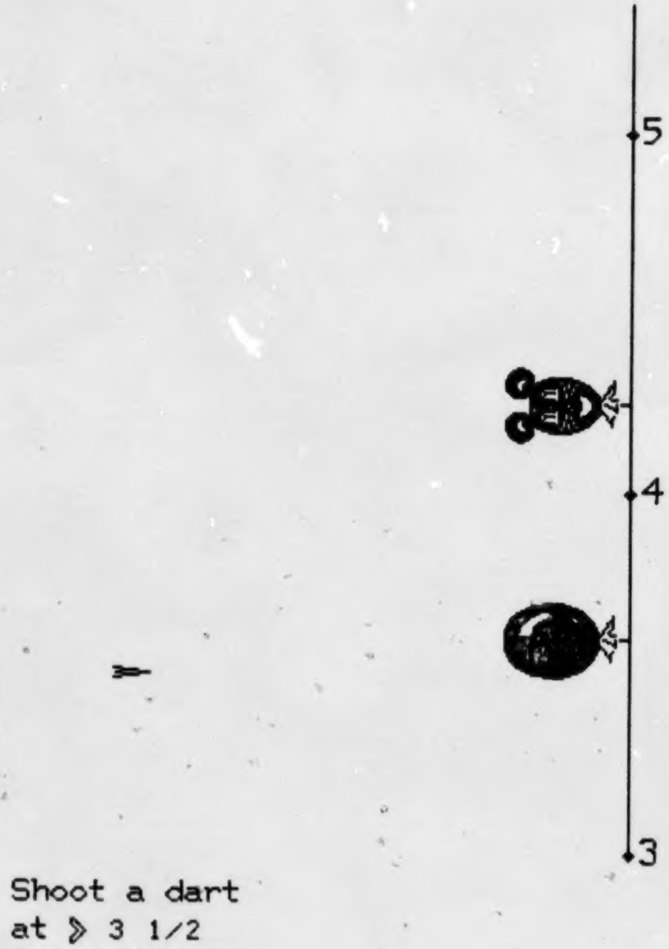
The standard PLATO V terminal[3] contains an 8080 microprocessor operating at 500 tips(thousand instructions per second) and 16k (k=1024) bytes of memory. The memory is divided into 8k bytes of read-only memory (ROM) which contains the terminal resident (operating system) and 8k bytes of random access memory (RAM) provided for user programs and/or data. Within the resident are:

a) programs for generating displays including a character plotter, line generator, and programs for erasing the display.
b) programs for servicing the keyboard, touch panel, serial communication port (PLATO network) and the parallel data bus.
c) programs for communicating with the PLATO system.
d) a diagnostic program for "debugging" local programs.
e) data for the standard PLATO character set.
f) a basic μTUTOR interpreter.(μTUTOR is a high level authoring language containing the most frequently used commands of the TUTOR language.)

The Off-Line PLATO Terminal

By adding an additional 8k of ROM and attaching a floppy disk, as shown in Figure 1, a PLATO V terminal becomes capable of executing PLATO lessons totally within the terminal. The additional ROM contains an expanded version of the uTUTOR interpreter and a floppy disk operating system while the floppy disk is used to provide up to 512k bytes of local storage for lessons and data.

The PLATO terminal may now be operated off-line, in student mode, and retain the ability to produce the sophisticated displays which formerly required on-line (dedicated) access to the central computer system. The terminal automatically pages in from the disk the code necessary to operate the program so



Shoot a dart
at ≫ 3 1/2

Figure 2a. Elementary school students learn about number lines by giving the mixed number which is required to make a dart break a balloon.

that lessons which are too long to reside in the terminal memory may be used.

Lessons are developed on-line in μTUTOR using the TUTOR editor in the same way regular TUTOR lessons are prepared. The compiled course material is then 'down loaded' to the terminal and stored on a floppy diskette for later use by students. Each diskette provides the equivalent of 32k words of disk storage on the central system.

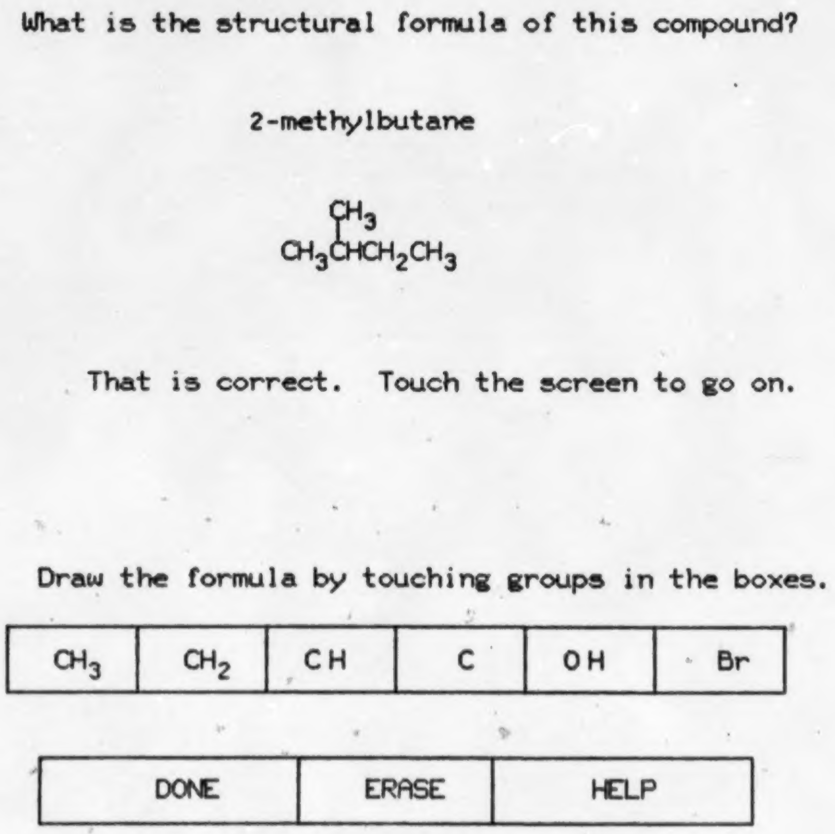
Because the lessons are now stored locally on the floppy disk rather than in the central computer, the bandwidth between the terminal and the data is increased from 120 to 30,000 bytes per second. This tremendous increase in bandwidth dramatically reduces the access time to new displays. Typical delays associated with getting information from the disk are less than 0.1 seconds. Execution is also rapid because the lesson material is stored on the disk in binary form instead of source code. The continuous availability of 500 tips of processing power also significantly increases the display generating speed, resulting in smoother animated displays. The character plotting rate, 3000 per second, is over 16 times that of PLATO IV. Lines may be drawn at rates of 100 to 1000 per second, depending on length. Circles may be computed and drawn at up to 12,000 points per second.

Off-Line Instructional Material

The capability of the off-line PLATO system may be judged by the types of programs which have been adapted to run in this mode which range from elementary school mathematics to university level chemistry, Russian, and veterinary medicine. A display from an elementary math lesson on number lines is shown in Figure 2a. In this math game the student enters the mixed number which is needed to make a dart break a balloon. A chemistry lesson in which the student constructs the 2-dimensional representation of an organic molecule is illustrated in Figure 2b. Here the display shows a special chemical keyboard which allows the student to draw complex structures by simply touching the screen. The high resolution display makes it possible to present spectroscopic data as shown in Figure 2c. Part of a Russian lesson which requires the use of the cyrillic alphabet is illustrated in figure 2d.

Ease of access to lessons by students is an important component of the successful use of CAI in the classroom. The disk management system for the off-line PLATO system incorporates those features which have been found necessary in the past 16 years of the development of PLATO.

In a classroom situation in which instruction is delivered off-line, dial-up or dedicated access to the central system by at least a few terminals would serve the important functions of providing access to the library of lessons stored



What is the structural formula of this compound?

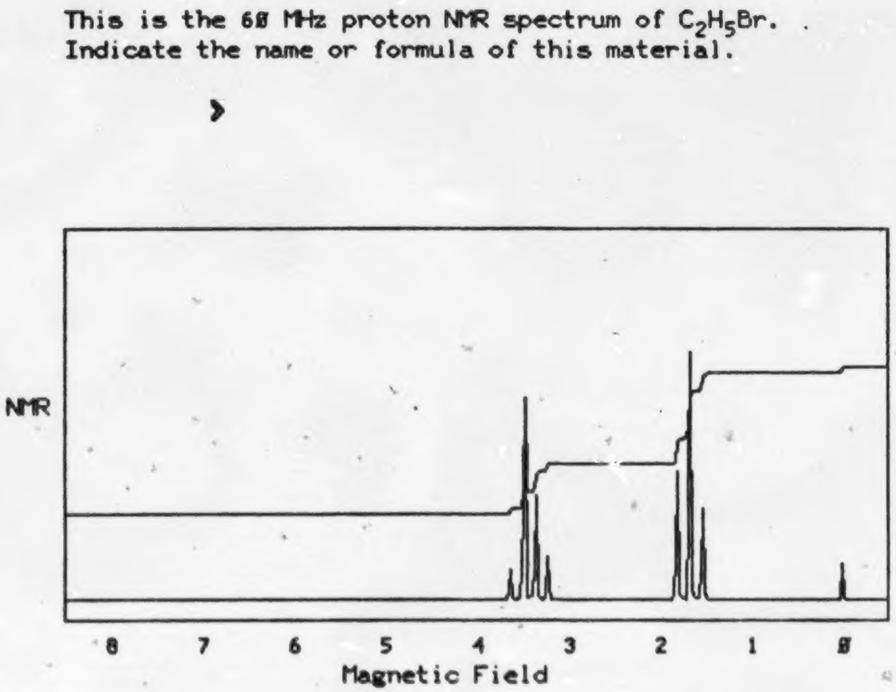
2-methylbutane

$$\begin{array}{l}\quad\;\; CH_3 \\ \quad\;\; | \\ CH_3CHCH_2CH_3\end{array}$$

That is correct. Touch the screen to go on.

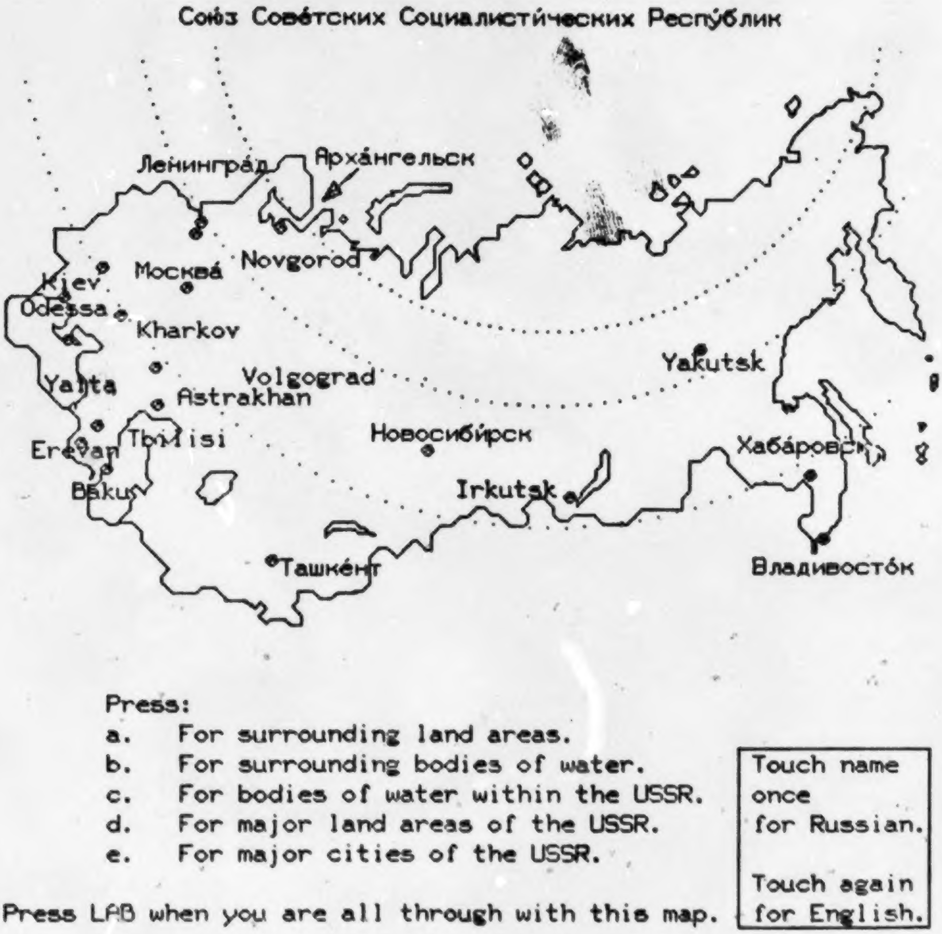
Draw the formula by touching groups in the boxes.

Figure 2b. As part of a lesson on the structures of organic compounds, students can draw a two dimensional structural formula by touching the groups shown in the boxes on the screen.



This is the 60 MHz proton NMR spectrum of C_2H_5Br.
Indicate the name or formula of this material.

Figure 2c. The high resolution of the PLATO display makes it possible to present detailed graphical data. Here the student is asked to interpret a proton magnetic resonance spectrum.


Сою́з Сове́тских Социалисти́ческих Респу́блик
Ленингра́д
Арха́нгельск
Москва́
Novgorod
Kiev
Odessa
Kharkov
Yalta
Volgograd
Astrakhan
Erevan
Tbilisi
Baku
Новосиби́рск
Irkutsk
Ташке́нт
Yakutsk
Хаба́ровск
Владиво́сток

Press:

a. For surrounding land areas.
b. For surrounding bodies of water.
c. For bodies of water within the USSR.
d. For major land areas of the USSR.
e. For major cities of the USSR.

Press LAB when you are all through with this map.

Touch name once for Russian.

Touch again for English.

Figure 2d. This lesson allows students to study the English and Russian names of major Russian cities.

in the central computer, revisions of programs in use, processing of large data bases, consultation with on-line experts, and communications with other users of the PLATO system.

This system demonstrates that it is possible, using relatively few resources, to deliver sophisticated CAI material while preserving all of the power of the PLATO system at just a phone call away.

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